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THE ANTS OF THE GENUS METAPONE FOREL.*

By William Morton Wheeler.

The singular genus *Metapone* was established by Forel, in 1911†, for an ant from Ceylon, *M. greeni*, characterized by a peculiar Ponerine habitus (resemblance to *Cylindromyrmex* and *Simopone*), scrobed head, supposedly 11-jointed antennæ in the male as well as in the worker and female, one-jointed maxillary and three-jointed labial palpi, terminally spinose or dentate middle and hind tibiæ and metatarsi and what he regarded as an unusually slender, strongly segmented, non-tuberculate larva, with long sparse hairs, and stout mandibles, and pupating without spinning a cocoon. He says of this genus, which he made the type of a new tribe, Metaponini: "I regard it as constituting a special section, which I place *provisionally* among the Ponerinæ and which I call Promyrmicinæ. Perhaps later it will be necessary to transfer it to the Myrmicinæ. I reserve my opinion in regard to this matter," etc.

A year later, Emery‡ examined *M. greeni* and its larva more critically and found that alcoholic specimens of the latter when properly softened and expanded had the usual shape of body, head and mouthparts of the Myrmicine larva and were furnished with long, serially arranged, hooked, dorsal hairs unlike any known Ponerine larvæ, but like many larval Myrmicinæ. He concluded that *Metapone* is a true Myrmicine ant and says: "It seems to me that the comparison of *Metapone* with *Cylindromyrmex* and *Simopone* on the one hand and *Sima* on the other,

* Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University. No. 159.

† Sur le genre Metapone n. g. nouveau groupe des Formicides et sur quelques autres formes nouvelles. Rev. Suisse Zool. 19, 1911, pp. 445–451, 1 Pl.

‡ Etudes sur les Myrmicinae. Ann. Soc. Ent. Belg. 56, 1912, pp. 94–105, 5 Figs.

as formulated by Forel should be reversed, that *Metapone* should be regarded as belonging to the subfamily Myrmicinæ and that the resemblance of the genus to *Pseudomyrma* and *Sima* is due to genetic relationship and not merely to convergent adaptation. I nevertheless accept Forel's section Promyrmicinæ but as a division of the Myrmicinæ and extend its scope to include two tribes, the Metaponini and Pseudomyrmicini." Apparently Emery reached this conclusion as a result of regarding *Metapone* as closely related to the African *Pachysima aethiops* Smith and especially to *P. latifrons* Emery.

As Forel's knowledge of the male and female of *M. greeni* was restricted to a study of pupal specimens, he could give no account of the venation of the anterior wings. In 1913, however, he described a second species, *M. sauteri*, from a female specimen taken in Formosa* and figured the fore wing, which has an open radial cell and a single cubital cell. This led him to incline to Emery's view and to suggest a resemblance between *Metapone* and the Myrmicine genus *Liomyrmex*.

In 1915 Forel described a third species of *Metapone* from Queensland, *M. mjöbergi*†, and I have since described two species, *M. bakeri*, from a female specimen taken in the Philippines‡ and *M. hewitti*, from male specimens taken in Borneo§. The latter species showed that the male *Metapone* really has 12-jointed antennæ and that Forel had evidently overlooked the second funicular joint in the male of *greeni*. Still more recently I have found two undescribed species, one from New South Wales and one from Queensland, among material sent me for study by the Museum of South Australia. Thus the genus *Metapone*, as at present known, comprises seven species.

Concerning the habits of these ants very little has been recorded. Mr. E. E. Green took the specimens of the type species "from galleries in a decayed branch, which was also infested by two species of termites." And Forel adds: "It lives, therefore, like *Cylindromyrmex*, in wood, with termites.

* H. Sauter's Formosa-Ausbeute. Formicidae II. Arch. f. Naturg. 79, 1913, pp. 183–202, 1 Fig.

† Results of Dr. E. Mjöberg's Swedish Scientific Expeditions in Australia 1910–1913, Ark. f. Zool. 9, 1915, pp. 1–119, 3 Pls. and 6 text Figs.

‡ Four New and Interesting Ants from the Mountains of Borneo and Luzon. Proc. New Eng. Zool. Club 6, 1916, pp. 9–18, 4 Figs.

§ The Ants of Borneo. Bull. Mus. Comp. Zool. 1919, 63, pp 43-147

We cannot deduce from this either that it is or is not a termitophagous species, but that it is seems very probable. At any rate, it inhabits dead branches like many termites and numerous tropical ants (*Leptogenys mucronata*, *Pseudomyrma künckeli*, etc.)"

Although none of the specimens of *Metapone*, except those of *M. greeni*, was accompanied by notes on their habits, I deem it very probable that all of the species form small colonies and live in the dead twigs and branches of trees near or actually in the galleries of termites, presumably of the genus *Calotermes* and prey on these insects or their young. That this is the case is indicated by the cylindrical shape of the body and the fact that the workers of some of the species (*greeni*, *mjöbergi* and *tillyardi*) are colored much like the termitophagous ants of the genera *Aëromyrma* and *Paedalgus*, while the females of others (*sauteri* and *leæ*), in having the head and thorax black and the gaster red, strikingly resemble the females of the termitophagous genera *Carebara* and *Ephebomyrmex*.

Returning to the question of the affinities of *Metapone*, I may say that I am unable to accept Forel's original view and that I find Emery's in part unacceptable. Forel's view is precisely stated in the two following quotations.

At page 448 he says: "The general form of the three sexes (of *Metapone greeni*) is cylindrical and altogether recalls the facies of the species of *Cylindromyrmex*. The analogy with *C. meinerti* Forel is very striking, notwithstanding the clypeus, which is absolutely different, and the postpetiole. The clypeus has a certain resemblance to that of *Simopone* in which it also terminates behind with an arcuate suture, but much less transverse and passing more posteriorly. In *Simopone* the frontal carinæ are also less separated. A certain distant resemblance to the species of *Sima* and *Pseudomyrma* is probably due to the convergence of an arboricolous life in cylindrical vegetable cavities. The relationship with the Ponerine genus *Cylindromyrmex* (*C. meinerti*) is certainly real and not due solely to the phenomena of convergence (mandibles, flat eyes placed behind the scrobes, antennæ, legs, petiole, sculpture, etc.)" And at page 452 he says: "In my opinion they (the Metaponini) should be placed directly between the Cylindromyrmicini and the Melissotarsini." The Cylindromyrmicini

are now placed by Emery with the Cerapachyi among the primitive Ponerinæ, whereas the *Melissotarsus* and *Rhopalomastix* are now regarded by both Emery and Forel as Myrmicinæ, and Forel would place them at the head of this subfamily "as being the most closely allied to the Ponerinæ."

I admit that *Metapone* closely resembles the Ponerine genus *Cylindromyrmex*, especially in the cylindrical shape of the body and head and the scrobes for the accommodation of the antennæ. Moreover, the habits of *Cylindromyrmex* and of the allied genus *Simopone* seem to be much the same as those of *Metapone*. According to Mayr*, *Cylindromyrmex striatus* Mayr (*C. brasiliensis* Emery) was collected by Hetschko in Santa Catharina, Brazil, "in wood in the galleries of a termite," and Arnold† recently described *Simopone marleyi* from three specimens taken by Marley at Durban "in hollow stems of the castor oil plant." A closer comparison of *Metapone* with *Cylindromyrmex* and *Simopone*, however, shows that the resemblances are merely superficial or convergently adaptive to this very peculiarity of habitat. The long, cylindrical body in various genera of wood-inhabiting ants is no more an indication of genetic affinities than is the similar shape so frequently and strikingly exhibited by various families of wood-boring Coleoptera (Ipidæ, Cleridæ, Bostrichidæ, Lymexylonidæ, some Erotylidæ, Trogositidæ, Buprestidæ, Cerambycidæ, Lucanidæ, etc.) As long ago as 1891 Forel seems to have been deceived by these superficial characters when he was writing his original account of the genus *Simopone*.‡ He there stated that "the resemblance of the genera *Cylindromyrmex* and *Simopone* to the genus *Sima* Roger, which belongs to the Myrmicides, is not a fact of convergence or of mimicry, but seems to me to be due to real affinities, notwithstanding the difference in the form of the pedicel. The genus *Simopone*, especially, with its very pronounced abdominal constriction, seems almost to form a transition to the Myrmicides, notwithstanding its Ponerid sting and pygidium." Here, again, the resemblance of *Cylindromyrmex* and *Simopone* to *Tetraponera* (*Sima* auct.) is manifestly due merely to similarity of habit, for the species of

* Südamerikanische Formiciden. Verh. zool. bot. Ges. Wien 37, 1887, p. 546.

† A Monograph of the Formicidae of South Africa I. Ponerinae and Dorylinæ Ann. S. Afr. Mus. 14, 1915, p. 21.

‡ In Grandidier's Histoire Phys. Nat. Polit. Madagascar 20, 1891, p. 141.

Tetraponera and of the allied genus *Pseudomyrma* live in cylindrical cavities or galleries in the branches or twigs of plants.

While I am of Emery's opinion that the species of *Metapone* are true Myrmicine ants and show no particular relationship to the Ponerinæ, I do not agree with Emery in accepting Forel's unfortunate term "Promyrmicinæ" or in associating the Metaponini as the first tribe of the Myrmicinæ with the Pseudomyrmicini in a section under that name. It seems to me that Emery is too much influenced by Forel's prepossessions. There is, in fact, little or nothing that is primitive or ancestral about *Metapone*, but much that is highly specialized and secondary, e. g., the shape of the antennæ and especially the reduction of the number of antennal joints in the male and female phases, the peculiar reduction of the palpal joints, the simplified venation of the fore wings, the peculiar structure of the petiole, postpetiole and legs, the vestigial condition of the eyes in the worker, etc. The larva is not only purely Myrmicine, but quite unlike that of *Pseudomyrma*, *Tetraponera* and *Pachysima*, as may be seen by comparison of Emery's figure (here reproduced as Fig. 2) with those in one of my recent papers.* Such study as I have been able to make of four species of the genus *Metapone* convinces me that it is an abberrant and highly specialized, though probably ancient genus of Myrmicinæ, neither primitive nor ancestral, without special affinities to the tribe Cylindromyrmicini or other Ponerinæ and moreover not even closely related to the tribes Peudomyrmicini. It should, of course, constitute an independent tribe, Metaponini, as Forel and Emery maintain, but its position among the other tribes of the Myrmicinæ is not easily determined. It might be placed provisionally between Emery's Melissotarsini and his Stereomyrmicini, which have 11-jointed antennæ in both male and female phases.

The following key will help in separating the six *Metapone* species of which the worker or female is known. *M. hewitti*, known only from the male, is redescribed below.

* A Study of Some Ant Larvae, with a Consideration of the Origin and Meaning of the Social Habit Among Insects. Proc. Amer. Phil. Soc. 57, 1918, pp. 295–343, 12 Figs.

KEY TO METAPONE SPECIES.

1. Clypeus with a narrow, projecting, rectangular anterior lobe, transversely truncated in front, concave at the sides, with acute tooth-like corners....2.

   Clypeus scarcely projecting anteriorly, without distinct lobe, bluntly or obscurely bidentate.....5.

2. Petiole broader than long, its posterior corners blunt, flattened and lobular; postpetiole transversely elliptical or sub-elliptical; color brown.....3.

   Petiole much longer than broad, its posterior corners produced as somewhat diverging teeth which are longer than broad at their bases; postpetiole subrectangular; color black, with red or brown gaster.....4

3. Mandibles 4-toothed; mesoepinotal suture very distinct and impressed; posterior corners of epinotum not swollen; sculpture of head and thorax rather coarse; brownish red, with castaneous gaster, female darker; length 5.9–8.9 mm.....*greeni* Forel.

   Mandibles 5-toothed; mesoepinotal suture indistinct; posterior corners of epinotum swollen; sculpture of head and thorax finer; pale brown, head darker; length, 7.6 mm.....*mjöbergi* Forel.

4. Body not greatly flattened; length 10.5–11.1 mm.; petiole and postpetiole longitudinally striate; black, with dark brown gaster.....*sauteri* Forel.

   Body much flattened; length 6.5–7 mm.; petiole transversely striate, postpetiole smooth; apical mandibular teeth smaller than the basal; brown black, with ferruginous red gaster.....*leæ* sp. nov.

5. Mandibles 5-toothed; posterior clypeal suture distinct; head and thorax longitudinally striate; petiole broadly and feebly excised behind; legs short, femora very broad; head and thorax castaneous; gaster and legs ferrugineous; length 5.5–6 mm.....*tillyardi* sp. nov.

   Mandibles 4-toothed; posterior clypeal suture obsolete; body very smooth and shining; petiole longer, deeply and angularly excised behind; legs longer, with narrower femora; black, with dark reddish brown legs; length 6.4 mm.....*bakeri* Wheeler.

1. **Metapone greeni** Forel.

Forel, Rev. Suisse Zool. 19, 1911, p. 449, Pl. 14, ♀ ♀ ♂ and larva; Emery, Ann. Soc. Ent. Belg. 56, 1912, p. 95, Fig. 1, larva.

(Figs. 1 and 2.)

Worker. Length 5.9–8.9 mm.

Head subrectangular, nearly one and one-half times as long as broad, with subparallel sides and moderately concave posterior border. Eyes small, elongate, in the largest individuals with about 15 ommatidia in their longest and about 10 ommatidia in their shortest diameter.

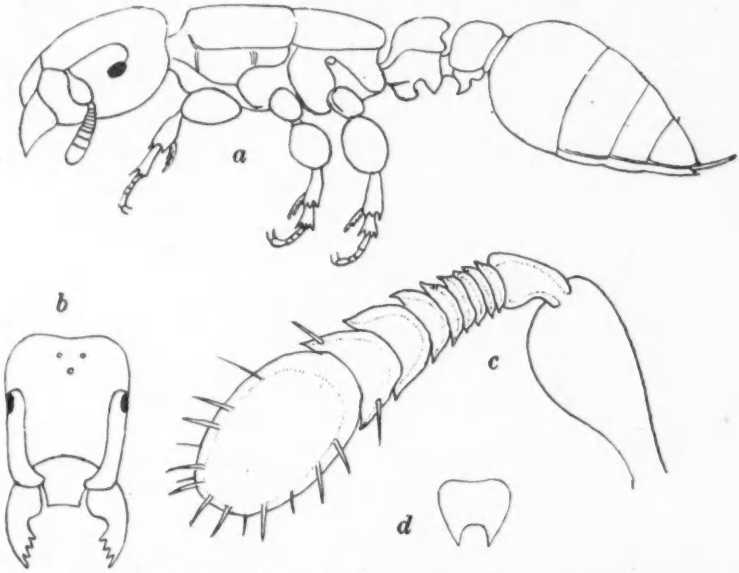

Fig. 1. *Metapone greeni* Forel (after Forel). *a*, worker; *b*, head of same from above; *c*, antenna of same; *d*, scutellum of male from above.

There are three ocellar pits, but no ocelli in the largest workers. Mandibles 4-toothed, with large basal lobe. Clypeus large, with subrectangular anterior lobe. Scape slightly surpassing the middle transverse diameter of the head, flattened and apically much dilated; funiculus much dilated and flattened at the tip, joints 2-6 at least three times as broad as long, 8 and 9 decidedly broader than long, the apical joint longer than broad and much longer than 8 and 9 together. Thoracic dorsum oblong, scarcely broader in front than behind, somewhat flattened above, submarginate on the sides. Promesonotal suture very indistinct, mesoepinotal suture distinct and impressed. Pro- and mesonotum subequal, each one and one-half times as broad as long,

together one and one-fourth times as long as broad; base of epinotum rather longer than broad, passing through an abrupt curve into the short, subvertical declivity. Petiole subcuboidal, rather flat above, widened behind, a little broader than long, its posterior border above deeply and broadly excised, its anterior and posterior surfaces truncate, the dorsal somewhat thicker than the ventral portion. Anteriorly it has a short peduncle and its ventral surface has in front a large, longitudinal rectangular, translucent lobe, followed by a strong tooth. Postpetiole broader and shorter than the petiole, one and three-fourths times as broad as long, rounded cuboidal, bearing on its ventral side a large tooth, followed by a welt. Gaster oval; sting long and stout. Femora greatly dilated, the posterior pairs scarcely one-third longer than broad; tibiæ and metatarsi short and broad.

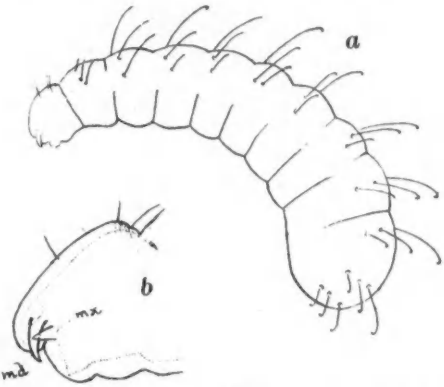

Fig. 2. *Metapone greeni* Forel. Larva (after Emery). *a*, lateral view; *b*, head of same; *md*, mandible; *mx*, maxilla.

Shining; head and thorax regularly and not coarsely longitudinally striated, with scattered, effaced punctures; the remainder of the body smooth, with fine, scattered, piligerous punctures.

Erect hairs yellowish red, short, very sparse on the body, almost lacking on the thorax, more abundant on the tibiæ and scapes. Pubescence reddish, sparse, very distinct on the gaster and pedicel, but scarce elsewhere.

Deep brownish red; gaster deep chestnut brown, sometimes blackish, with red tip. Small workers sometimes paler (immature?).

Female (mature pupa). Length 9.5 mm.

Eyes very large, occupying nearly one-half the sides of the head, moderately convex. Mesonotum and scutellum flat, small, together forming scarcely half the thoracic dorsum. In other respects like the worker, but with the head a little longer. Dark brown, nearly black.

Male (mature pupa). Length 7 mm.

Mandibles small, tridentate. Clypeus very large, convex in front, flattened behind. Head slightly longer than broad; eyes occupying more than half its sides. Frontal carinæ parallel, as far apart as they are from the lateral borders of the head. Front truncated anteriorly and separated from the preocellar space by a transverse carina connecting the frontal carinæ. Antennal scrobes small, marginate behind and laterally. Antennal scape very short, scarcely longer than broad; first funicular joint very small, globular, broader than long, the remaining joints cylindrical, the more basal a little broader than long, but increasing gradually in length, the last twice as long as broad. Thorax as broad as the head, rather flat. Mesonotum with Mayrian furrows; scutellum behind with two short, flat, horizontal teeth. Epinotum subcuboidal, its base longer than its declivity. Petiole and postpetiole as in the worker, but the former much broader than long, more rounded and not emarginate behind, with a small anteroventral tooth, the postpetiole unarmed below. Gaster elongate. Legs of the ordinary form, not dilated.

Head and thorax opaque or subopaque; longitudinally rugose, with reticulate interrugal spaces; sides of thorax striated. Clypeus coarsely and transversely rugose. Pedicel and anterior half of gaster densely reticulate-punctate and opaque or subopaque; posterior half of gaster becoming more shining. Postpetiole longitudinally rugose above and coarsely rugose on the sides like the posterior portion of the epinotum.

Erect hairs very oblique on the appendages, nearly appressed, almost absent and very short on the scapes. Pubescence somewhat more abundant than in the worker.

Black; margins of gastric segments, genital valves, tarsi, tibiæ and scapes sordid yellow or reddish; funiculi brown.

Type-locality: Peradenyia, Ceylon (E. E. Green).

2. **Metapone mjoebergi** Forel.

Forel, Ark. f. Zool. 9, 1915, p. 36 ♂ ♀.

Worker. Length 7.6 mm.

Somewhat smaller than *greeni*. Mandibles 5-toothed, their outer margin feebly convex and their basal lobe smaller. Anterior lobe of clypeus much shorter than in *greeni* and *sauteri*, but also rather rectangular. Head rectangular, about one-third longer than broad, not broader behind than at the base of the frontal carinæ, only anteriorly somewhat narrower, with nearly straight sides and feebly concave posterior border (in *greeni* broader behind and more convex laterally, longer in *sauteri*). Scape and funiculus more slender than in *greeni*, about as in *sauteri*. The very small, perfectly flat eyes have only a few indistinct ommatidia and lie as in *greeni* below the hind end of the scrobes, but are much smaller. Whole head in profile appearing as if very obliquely truncated anteriorly, i. e., with the anterior half of the clypeus much more abruptly declivous than in *greeni* and *sauteri* so

that the clypeus does not seem to stand away from the mandibles. Thorax very feebly convex, two and one-fourth times as long as broad, with parallel sides. Anterior corners of pronotum obtuse; posterior corners of the concavely emarginate epinotum protruding and swollen, a condition not seen in *greeni*. Promesonotal suture absent, mesoepinotal suture feebly indicated (deeply impressed in *greeni*). Petiole much broader and shorter than in *greeni*, as broad as the epinotum, not quite twice as broad as long, its anterior border feebly, its posterior border deeply concave, narrower in front than behind, where its angles extend out as flat, lobular projections. It is truncated anteriorly and posteriorly and even somewhat concave in front, and bears ventrally only one strong longitudinal lobe. Postpetiole not broader than the posterior border of the petiole, scarcely one and one-half times broader than long, rounded on all sides, only about half as broad as the gaster, with two teeth below. Legs of the same shape and quite as broad as in *greeni*, the tibiæ shorter and stouter than in *sauteri*.

Sculpture of body, especially of the head, somewhat weaker and more finely longitudinally striate than in *greeni;* petiole and gaster distinctly more densely punctate. Mandibles nearly smooth, feebly striate and sparsely punctate.

The gaster and thorax exhibit a very short, fine, rather abundant, erect pilosity, which partly passes over into the pubescence and is sparser on the posterior portion of the head. There are only a few long hairs.

Pale brown, head dark brown; appendages brownish yellow.

Female (dealated). Length 7.9 mm.

Scarcely distinguishable from the worker, only much darker, brownish black, and with more distinct sutures outlining the mesonotum and scutellum. Hind corners of epinotum less protuberant, eyes large, ocelli present. Postpetiole somewhat broader than in the worker.

Type-locality: Malanda, Queensland (E. Mjöberg).

3. **Metapone sauteri** Forel.

Forel, Arch. f. Naturg. 79, 1913, p. 189, Fig. ♀.

Female. Length 10.5–11.1 mm.

Head rectangular, at least one and one-half times as long as broad, with straight sides and feebly concave posterior border. Eyes much as in *greeni*. Mandibles much longer and broader, with straight 5-6-toothed terminal border and longer and broader basal lobe. Clypeus with more distinct posterior suture, its anterior rectangular lobe much longer than in *greeni*, with perfectly straight anterior border, concave sides and acute corners. Frontal groove distinct. Antennæ very similar to those of *greeni*, but somewhat longer and narrower, especially the scape. Thorax decidedly narrower than the head, but otherwise as in *greeni*, the epinotum, however, much longer, nearly one and one-half times as long as broad, more strongly convex and less strongly marginate on the sides. Petiole also longer, much longer than broad, posteriorly with

two longer and more slender teeth, which are longer than broad at their bases. Postpetiole more rectangular than in ***greeni***, nearly as long as broad. Gaster much broader, nearly twice as broad as the postpetiole, first segment nearly three times as long as the postpetiole. Lobes and teeth on the ventral surface of the petiole and postpetiole precisely as in ***greeni***, also the teeth on the posterior tibiæ and metatarsi, but the femora, especially the anterior pair, twice as long as broad. Wings with a single cubital cell, a discoidal and a long radial cell, the latter slightly open at the tip; radial and cubital veins separating at the tip of the cubital cell.

Longitudinal striation of the head and thorax much as in ***greeni***, but somewhat coarser, the head less punctate. Petiole and postpetiole not only punctate as in ***greeni***, but also sharply longitudinally striate; the striæ on the petiole arcuate behind. Gaster shining, sparsely punctate and feebly and finely coriaceous.

Hairs sparse, reddish yellow, both erect and appressed on the body; appressed hairs on the head and thorax very scarce.

Black; antennæ and gaster dark reddish brown; tibiæ and tarsi reddish; femora and coxæ brownish. Wings brownish, with brown veins and pterostigma.

Type-locality: Sokutsu, Banshoryo District, Formosa (Hans Sauter).

4. **Metapone leæ** sp. nov.

(Figs. 3 and 4.)

Female. Length 6.5–7 mm.

Head one and one-half times as long as broad, distinctly narrower at the anterior corners than behind, the sides feebly convex and the posterior border nearly straight; the upper surface very flat, in profile about two and one-half times as long as high. Mandibles convex, their basal lobes large, their terminal borders with a series of five teeth, smallest apically and largest basally. Clypeus flat, with a long projecting median lobe, which has a straight, transverse anterior border, concave sides and acute corners. Eyes rather large, but evidently smaller than in ***greeni*** and ***sauteri***. Ocelli small, near the occipital border. There is a longitudinal, impressed line, bordered on each side by a ruga, representing the frontal groove, extending from the posterior border of the clypeus to the anterior ocellus and growing deeper posteriorly. Antennæ rather stout, flattened; scape elliptical, somewhat more than twice as long as broad; funiculus with 3-jointed club, first joint as long as broad, joints 2-7 transverse, broader than long, terminal joint about as long as the two preceding joints together. Thorax elongate, subhexagonal, fully two and one-half times longer than broad, very flat above, four times as long as high, broader through the wing insertions where it is as broad as the head. Humeri of pronotum bluntly angular; mesonotum slightly concave behind, as broad as long, with the scutellum on the same level as the base of the epinotum, which is longer than broad, narrower behind than in front,

with straight sides and broadly and feebly excised posterior border. In profile the declivity is vertical and only about one-third as long as the base into which it passes through an abrupt curve. Petiole shaped like a mammalian vertebra, seen from above only half as broad as the epinotum at its base, one and one-third times as long as broad, with convex rounded anterior and slightly concave lateral and posterior borders, the posterior corners produced as two long blunt, diverging teeth and the middle of the posterior border above elevated as a low

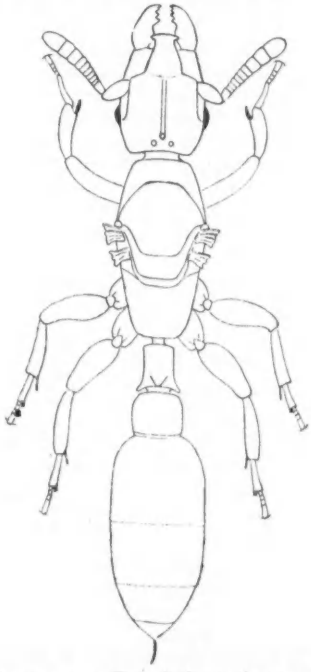

Fig. 3. *Metapone leæ* sp. nov. Female from above, with wings removed.

angular tubercle. In profile the anterior and posterior surfaces are truncated, the anterior and lateral surfaces concave, the ventral surface with two small angular, widely separated projections. Postpetiole from above nearly square, a little broader than long, a little broader than the petiole through its posterior teeth, feebly convex above, sharply truncated anteriorly, ventrally with a stout angular projection followed by a prominent transverse welt. Gaster narrow, twice as broad as the postpetiole, two and one-half times as long as broad, flattened dorsoventrally, the first segment as long as broad. Legs short, shaped much as in ***greeni***, with apically dentate posterior tibiæ

and metatarsi. Wings short (5 mm. long), with the same venation as in ***bakeri***, the radial cell being slightly open at its tip and the radial and cubital veins fused for a short distance beyond the tip of the cubital cell.

Shining; mandibles smooth, finely and sparsely punctate. Clypeus, head and thorax longitudinally striate; the striæ on the clypeus fine, on the upper surface of the head separated by smooth areas, especially on the sides of the front. On the sides of the head, however, and in the scrobal cavities the striæ are very sharp and regular, and curve around the antennal insertions. Neck transversely reticulate-rugulose. Rugæ

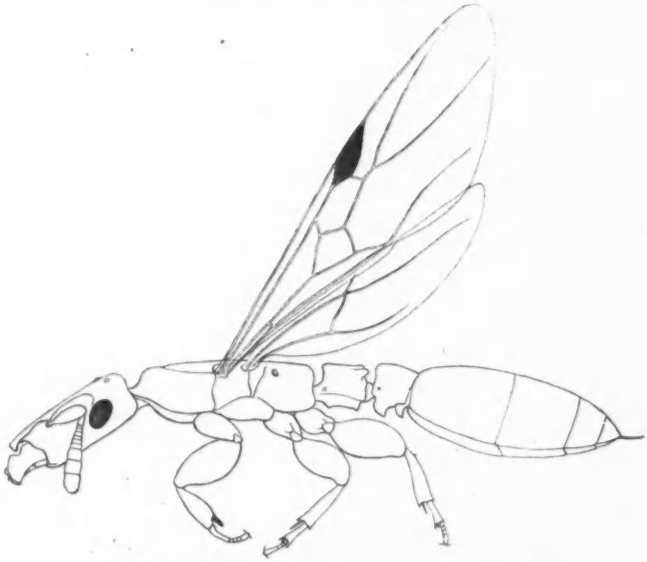

Fig. 4. *Metapone leæ* sp. nov. Female, lateral view.

on the pro- and mesonotum and scutellum sharp and regular, interspersed with a few punctures, rugæ on the base of the epinotum very fine, diverging behind, the surface also with coarse scattered punctures. Sides of thorax obliquely and finely striate. Petiole very finely and densely transversely striate above and also with a few coarse, scattered punctures. Postpetiole and gaster smooth and shining, with very fine, sparse, piligerous punctures. Legs shining.

Hairs yellowish, short, sparse, bristly, erect or suberect, of uneven length, longest on the postpetiole and gaster; pubescence coarse, very sparse on the thorax, more distinct on the gaster. Hairs on the legs short and sparse, more or less oblique.

Brownish black; mandibles, antennæ, clypeus and anterior lobes of frontal carinæ deep red; gaster and legs paler, ferruginous red; sides of thorax and lower surface of petiole and postpetiole somewhat castaneous. Wings brownish hyaline, with black pterostigma and brown veins.

Described from 22 specimens taken by Mr. A. M. Lea on Mt. Tambourine, Queensland. (Museum of South Australia).

This species is most closely related to *sauteri*, but is much smaller and is very distinct in the extremely flat, narrow body, differently sculptured petiole and postpetiole, paler gaster, etc.

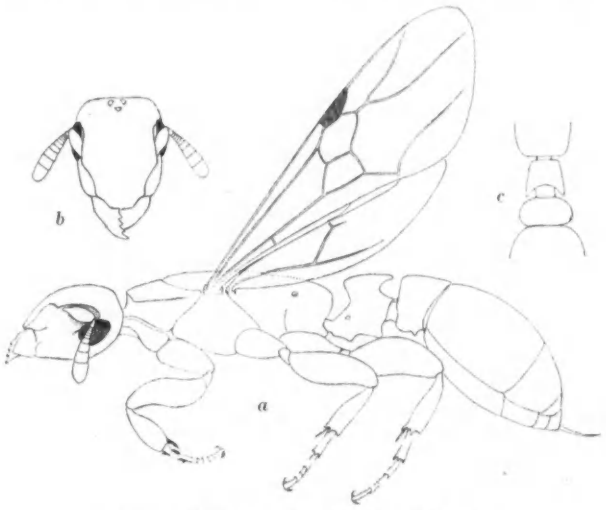

Fig. 5. *Metapone bakeri* Wheeler. Female.
a, lateral view; b, head, dorsal view; c, petiole and postpetiole.

5. **Metapone bakeri** Wheeler.

Wheeler, Proc. New Eng. Zool. Club 6, 1916, p. 10, Fig. 1. ♀.
(Fig. 5.)

Female. Length 6.4 mm.

Head less than one and one-fourth times as long as broad. Mandibles short and convex, 4-toothed, with small basal lobe. Clypeus convex, not marked off by a suture behind, its median lobe short and broad, with a blunt, tooth-like projection on each side. Antennæ with very distinct 3-jointed club, the two basal joints of which together equal the terminal joint. Thorax narrower than the head, nearly three times as long as high, its sides submarginate above; pronotum with subangular humeri, mesonotum feebly convex, together with the scutel-

lum broadly elliptical, longer than broad. Petiole from above a little longer than broad, broader behind than in front, marginate on all sides, with straight anterior and lateral borders, the posterior border deeply and somewhat angularly excised; in profile anvil-shaped, fully one and one-half times as high as long, its ventral surface with two large blunt angular projections. Postpetiole transversely elliptical, nearly twice as broad as long, ventrally with a blunt projection in front and a small tooth behind. Gaster small, suboblong. Legs short, but the femora much narrower than in the other species. Wings rather short, the radial cell narrowly open at the tip, the radial and cubital veins fused for a short distance beyond the apex of the cubital cell.

Extremely smooth and shining throughout, with sparse, very inconspicuous, piligerous punctures on the dorsal surface; posterior portion of antennal scrobes densely, longitudinally striate.

Hairs whitish, short, sparse, erect, nearly lacking on the pleuræ, most conspicuous on the gaster and legs.

Black; mandibles tinged with red; antennæ, fore legs, tibiæ, tarsi, tips and bases of middle and hind tibiæ reddish castaneous. Wings feebly infuscated, especially along the anteroapical margin; veins resin-colored; pterostigma dark brown.

Type-locality: Mt. Banahao, Luzon Island, Philippines (Prof. C. F. Baker).

This species differs from all the others in its highly polished, non-striate head and thorax, dark color, more slender legs, smaller size, etc. In my original description and figure the radial cell of the fore wing is represented as closed at the tip. It is really narrowly open. I have corrected the error in the figure as here reproduced.

6. **Metapone tillyardi** sp. nov.

(Fig. 6.)

Worker. Length 5.5–6 mm.

Head subrectangular, about one and one-fourth times as long as broad, a little broader behind than in front, with straight sides and very feebly concave posterior border. Eyes very small and indistinct, flat, at the lower posterior border of the scrobes. Clypeus rectangular, evenly convex anteroposteriorly, continuing the feeble convexity of the head, a little narrower in front than behind, with straight sides, separated behind from the head by a distinct suture, its anterior border scarcely produced as a lobe, bluntly bidentate in the middle. Each side of the clypeus overarches a cavity confluent with the scrobe and becomes continuous with the frontal carina which as in the other species extends to about the posterior fourth of the head. There is a distinct impressed line representing the frontal groove and extending to the posterior fifth of the head. Mandibles stout, their external borders rather straight, the apical border oblique, with five teeth, those at the apex largest,

the basal lobe small. Antennæ short, flattened, the scape elliptical, scarcely more than twice as long as broad; funiculus with distinct 3-jointed club, first joint longer than broad, joints 2–7 small, transverse, terminal joint a little longer than the two preceding joints together. Thorax regularly oblong, two and one-half times as long as broad, a little narrower than the head, with straight parallel sides, blunt anterior corners and concave posterior border, representing the boundary between the base and declivity of the epinotum which is square. The dorsal surface is flattened, bluntly submarginate on the sides, the pleuræ

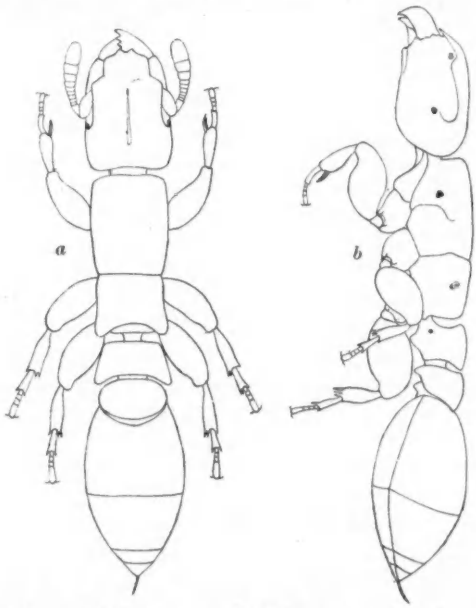

Fig. 6. *Metapone tillyardi* sp. nov. Worker. *a*, dorsal; *b*, lateral view.

concave. There is an extremely faint trace of a promesonotal suture; mesoëpinotal suture distinct, rather sharply impressed, especially on the sides. In profile the thorax is about two and one-half times as long as high, vertically truncated anteriorly and posteriorly, the latter truncation being the epinotal declivity, the sides of which are marginate but not swollen above. Petiole from above as broad as the epinotum and twice as broad as long, narrower in front than behind, with straight anterior and lateral borders and broadly excised posterior border, the posterior corners flattened and lobe-like; in profile the segment is truncated anteriorly and posteriorly, with the anterior and lateral surfaces strongly concave, the ventral surface bearing a single stout, triangular

projection. Postpetiole a little narrower than the petiole, transversely elliptical, twice as broad as long and more than half as broad as the first gastric segment, ventrally with two blunt transverse projections. Gaster short, one and two-thirds as long as broad, first segment somewhat shorter than broad. Legs very short, flattened; femora very broad, elliptical, tips of middle and hind tibiæ and metatarsi dentate as in the other species.

Shining; mandibles striato-punctate, basally smoother and sparsely punctate. Clypeus, head and thorax regularly and rather finely longitudinally striate; the posterior fourth of the head smooth and very shining. Interspersed with the striæ on the head are a few coarse punctures, arranged in rows, but becoming sparse on the occiput. The striæ on the pro- and mesonotum are somewhat finer and more regular than those on the head, on the base of the epinotum they are still finer and merge posteriorly into lines of punctures diverging to the posterior corners and into scattered punctures on the declivity. Sides of thorax obliquely striate. Petiole, post-petiole and gaster punctate, the gaster more finely. Legs smooth and shining, with very fine, sparse punctures.

Hairs yellow, in the form of sparse pubescence on the head and thorax, becoming conspicuously longer, more abundant and suberect on the gaster and especially on the sides of the petiole and postpetiole. There are also a few short erect hairs on the head and thorax. Legs with very short, rather bristly hairs, oblique on the tibiæ.

Rich castaneous brown; mandibular teeth and lateral borders of clypeus and anterior border of head black; antennæ a little paler brown; gaster and legs ferrugineous.

Described from 10 workers taken at Dorrigo, New South Wales (Museum of South Australia).

This species, which I dedicate to my friend, the eminent Australian entomologist, Dr. R. J. Tillyard, resembles *bakeri* most closely in the structure of the head and clypeus, but in color and sculpture it is more like *greeni* and *mjöbergi*, though sufficiently distinct from either.

7. **Metapone hewitti** Wheeler.

Wheeler, Bull. Mus. Comp. Zool. 1919, 63 p. 62♂.

(Fig. 7.)

Male. Length 6–7 mm.

Body long and slender. Head as broad as long, evenly convex and rounded behind, without posterior corners; cheeks very short; eyes moderately large, but not very convex; ocelli rather small. Mandibles small, but well developed, their external borders slightly sinuate basally, convex at the tips, apical and basal borders distinct, subequal, the former with four subequal teeth. Clypeus large, convex, somewhat broader than long, slightly depressed or flattened posteriorly. Front

truncated anteriorly, with a transverse crest or carina separating it from the preocellar space and connecting the frontal carinæ, which are prominent, nearly straight, subparallel and as far apart as they are from the lateral borders of the head. Posteriorly each carina curves forward medially of the eye as a distinct ridge and terminates opposite its anterior end, thus enclosing a small, shallow, elliptical scrobe about the base of the antenna. Antennæ 12-jointed; scape very small, about twice as long as broad; first funicular joint also very small, broader than long, subglobular; second joint considerably larger but also broader than long, the remaining nine joints stout, cylindrical, distinctly longer than broad, increasing somewhat in length distally, terminal joint nearly as long as the two preceding joints together, with tapering tip. Thorax long, narrower than the head through the eyes.

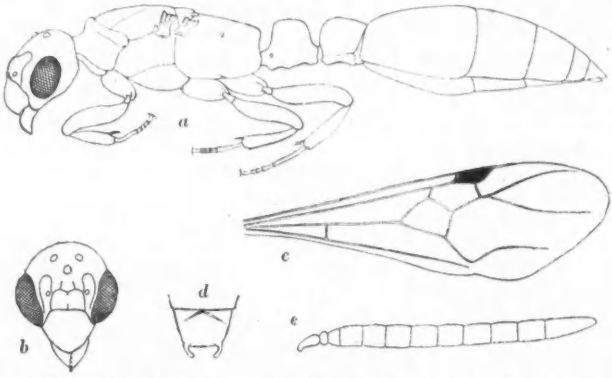

Fig. 7. *Metapone hewitti* Wheeler. *a*, male in profile; *b*, head, dorsal view; *c*, fore-wing; *d*, scutellum, dorsal view; *e*, antenna.

Pronotum well-developed, truncated in front; mesonotum and scutellum somewhat flattened above, the former with distinct Mayrian furrows, the latter on each side near its posterior border with a peculiar blunt, spatulate spine, slightly curved inward at the tip. Epinotum longer than broad; subrectangular from above, its base horizontal and twice as long as the vertical declivity into which it passes through an abrupt curve, the sides of the base and of the declivity above coarsely and rather irregularly marginate. Petiole with a short, stout peduncle anteriorly, and a thick cuboidal node, which is a little longer than broad and slightly higher in front than behind, with truncated anterior and posterior and rounded dorsal and lateral surfaces. Seen in profile its ventral margin is slightly bisinuate, with a small triangular tooth at the anterior end of the peduncle. Postpetiole distinctly broader than the petiole and broader than long, transversely elliptical, in profile truncated anteriorly, convex and rounded above, its ventral border unarmed, nearly straight. Gaster elongate elliptical, with straight anterior

border and tapering tip. Genitalia completely retracted; cerci apparently absent; pygidium and hypopygium short and pointed. Legs short, of the usual simple form, without the tibial and metatarsal teeth or spines of the worker and female; spurs of the middle and hind tibiæ simple, blunt at the tip. Tarsal claws very small, strongly curved, nonpectinated. Wings very short (4.5 mm.), with a well-developed discoidal cell, a single cubital cell and the radial cell slightly open at the tip. Pterostigma large and conspicuous.

Subopaque; mandibles opaque, longitudinally rugose and very finely punctate. Head reticulate-rugose, the clypeus more coarsely, though not transversely as in *greeni*. Front behind its anterior truncation with regular longitudinal rugæ converging to the anterior ocellus. Antennal scrobes less distinctly longitudinally rugose. Upper surface of mesonotum and scutellum and sides of thorax sharply and regularly longitudinally rugose, on the mesonotum with elongate, shallow foveolæ in the narrow interrugal spaces. Dorsal surface of epinotum, including the upper portion of the declivity with extremely coarse reticulate rugæ, some of which are clearly transverse. Petiole above less coarsely and even more irregularly rugose. Postpetiole and gaster very finely and densely punctate, with superimposed small, sparse and very regular piligerous punctures.

Hairs grayish brown, rather abundant, erect on the head, thorax and petiole, mostly subappressed or oblique on the postpetiole, gaster and legs. Antennal funiculi with very short fine hairs, or pubescence. Wings minutely hairy.

Black; mandibles, antennæ, legs and tip of gaster reddish brown, the tarsi slightly paler. Wings grayish hyaline with slightly infuscated tips and anterior margin; veins sharply defined, brown; pterostigma dark brown.

Type-locality: Kuching, Borneo (John Hewitt).

The four males from which this species was described were taken by Mr. Hewitt in 1908 and though they have been in my collection ever since, I was unable to assign them to any genus till Forel published his description and figures of *Metapone greeni*. Though closely related to the male of this species, *hewitti* differs nevertheless in having 4-toothed mandibles, a different sculpture, especially on the clypeus, and very different spines on the scutellum. The antennæ are certainly 12-jointed as shown in the accompanying figure. Forel evidently overlooked the second funicular joint in the mature pupal males of *greeni* which he examined. There is a possibility, of course, that *hewitti* may be the male of *sauteri* or *bakeri*, though it seems to be too small to be the male of the former and too opaque to belong to the latter species.

NOTES ON THE MALE GENITAL SYSTEM IN CERTAIN LEPIDOPTERA.*

By Herbert Ruckes, A. M.

INTRODUCTION.

Changes going on in organisms, whether studied grossly or minutely, have always been interesting subjects and many times astonishing truths have been revealed, where they were least expected to occur.

A great deal of the work carried on in entomological histology, especially under the heading of metamorphosis, has been relative to the muscular system, alimentary tract, adipose tissue, etc., while little attention has been given to other equally important systems. This is true of the reproductive system; so for this reason a study of the morphological and histological metamorphosis of the male genital tract in certain Lepidoptera was attempted.

The study was worked out under the direction of Professor W. A. Riley, to whom the writer is indebted for his prolonged patience and valuable criticism, and for the use of prepared slides. The writer also wishes to thank Professor Lester W. Sharp for his advices regarding the subject of spermatogenesis and for the use of his slides of maturation mitosis in insects. To Mr. John R. Eyer thanks are also due for use of his valuable slides of the genitalia of a large number of Lepidoptera.

The Lepidoptera were chosen to be worked on, for the metamorphosis could be readily controlled, by artificial means; and besides, this group shows apparently a greater diversity in the form of the genital system than most other orders. The Saturniidæ were chosen because when the study was first begun, they were most abundant.

Studies in the morphology and internal anatomy of insects date back to the earliest zoologists. Dissection of forms, however, did not properly commence till the advent of the microscope, so that we find the first worker on the genital system to be Malpighi (1669) whose treatise on the internal

* Contribution from the Entomological Laboratory of Cornell University. This paper is part of a thesis (by title, On the Metamorphosis of the Genital System in the Saturniidae) presented as part requirement for the degree of Master of Arts.

structure of *Bombyx mori* Linn. is now a classic. From that date onward we find little concerning the genital system till, in 1815, Herold produced his paper on the metamorphosis of *Pieris brassicæ* Linn., including other systems besides the reproductive. This paper formed the basis for subsequent work on the genital tract for it discussed the peculiar migration of the testes to a median plane and, there, complete fusion into a spherical body. It has been proved that this condition is by no means typical of all Lepidoptera, being representative of only the higher Rhophalocera. From the time of Herold's work till 1865 seems to be a more or less stagnant period for work of this sort. In 1865 Bessels published a few observations. From the morphological point of view the greatest contributions have been given by Chlodkovsky (1880-1913). Though short, these papers are thorough and explicit, explaining the evolution of the Lepidopterous genital tracts and their genealogical relationship to those of other orders. Since 1884, histological and cytological methods, combined with a continued increase of our knowledge of chromosomes and chromosome reduction, have led to the production of a vast amount of work and a large number of observations on all groups of insects. A great deal of this work has been restricted to the study of the maturation of sex cells, regardless of the structure and function of the surrounding tissues. Those doing the most comprehensive general studies since 1884 are LaValette St. George, Verson, Blatter, Berlese, Toyama and at a recent date (1913) Zick. The views and criticisms of these authors will be discussed as their particular points come up.

METHODS AND MATERIAL.

As above stated the Saturniidæ furnished the basis of the following study, though they were by no means the only forms observed. The following is a list of species that were used:

LEPIDOPTERA.

Philosamia cynthia Drury.
Samia cecropia Linn.
Callosamia promethia Drury.
Thelea polyphemus Cramer.
Pieris (*Pontia*) *rapæ* Linn.
Anosia plexippus Linn.
Vanessa antiopa Linn.

ORTHOPTERA.

Dissoteira carolina Linn.

HEMIPTERA.

Anasa tristis DeGeer.
Euschistus fissilis Uhler.
E. variolarius Stal.
Nezara viridula Stal.

By far the greatest part of the work was done on *P. cynthia*, since it was most readily available. *S. cecropia* offered the best material to follow out morphological changes—being the largest form. Material was procured at Ithaca and New York City.

For various ends, various technique was used. The material for spermatogenesis was killed and fixed in Benda's fluid, Zenkers, Gilson's or Herman's mixtures. Pereyni's reagent was found to be very good for synaptic stages of mitosis. A new mixture, formulated as follows, fixed "ring" stages better than any of the more common solutions:

2% copper sulphate	3 parts
2% platinum chlorid	2 parts
Acetic acid	6–10 drops to every 100 c. c.
Water (distilled)	10 parts

This solution is strictly a nuclear fixer. For the study of the tissues other than the germ cells, Gilson's or Herman's mixtures were employed.

Of the stains, Weigert's copper haemotoxylin was found best, this staining cytoplasm with as much exactness as the nucleoplasm. Mallory's connective tissue stain was indispensable for the muscular and fibrous coats of the various organs, especially the coats of the testis. Delafield's haemotoxylin counterstained with picro-fuchsin was found to be very good for determining the presence of a cuticula covering.

In making dissections, especially during the larval and early pupal periods, when the organs of the genital system are very delicate and very difficult to see, the preparations were lightly stained with Delafield's haemotoxylin, the stain being dropped on the dissection after the water had been poured out of the pan. In preparations made in this way, the finer organs like the vasa deferentia, ligaments, and nerves, could be followed along their course. These structures stain deeply, while the fat lobules do not.

In order to make a more detailed study of the nerves investing the caudal portion of the abdomen, specimens were injected with 1% Grübler's "B-X" methylene blue in a .9% salt solution and allowed to remain so treated, in a living condition for from twelve to twenty-four hours. The earlier stages were found to take up the stain more readily than the adults. In adults thirty-six hours were required to have this *intra vitam* method take effect.

PARTS OF THE ADULT MALE GENITAL SYSTEM.

In insects the male reproductive system consists of a pair of testes, a vas deferens, leading from each testis into a set of ducts that vary greatly in different groups of insects (Cf. Berlese *Gli Insetti*, Figure 1087), and a penis. The testes themselves are composed of testicular tubes. These tubes may be numerous or few; in the Lepidoptera there are four; the tubes also may be separated (*Hepialus*, Fig. 1A) or they may be fused (*Philosamia*, Fig. 1 B and E, Fig. 2), and in some cases the two testes may approach the median plane and fuse *Pieris*, Fig. 1 D). In all cases the testicular tubes are homologues of the ovarian tubes. In the Saturniidæ the testes lie in a latero-dorsal position, close to the alimentary canal, just under the fifth and sixth segments of the abdomen. They are reniform in shape, the convex side of each, called the apical region, being mesad; the concave region known as the hilum lies ectad, and is the junction of the vas deferens and the four testicular tubes (Fig. 3). The vasa deferentia are long irregular tubes, extending caudad to the eighth segment, where each passes through the loop-hole of the tenth abdominal nerve (Fig. 4, Vd). After passing through the nerve each turns cephalad to the seventh segment where it unites with the seminal vesicle. The seminal vesicles we may consider as distended portions of the vasa deferentia, each joined anteriorly to a long convoluted tube known as the accessory gland; posteriorly they unite to form the upper end of the ejaculatory duct. The ejaculatory duct is really in two parts; the upper end which in early pupal stages may readily be seen to consist of two approximated short tubes (prolongations of the seminal vesicles) is known in the adult as the *ductus ejaculatorius duplex;* the posterior and longer portion, which is an invagination of the ectoderm (it bears a cuticula or chitinous lining), is known as the *ductus ejaculatorius simplex*, and terminates in a very muscular "bulb," the *bulbus ejaculatorius* at the base of the penis. This last named organ is the caudal extremity of the entire genital system. It is wholly chitinous, bearing various types of prolongations, and is connected with the body wall by means of muscles. It is capable of extrusion during copulation. (The adult system is figured in Fig. 1E).

Of the parts of the reproductive system, the germ cells, the ductus ejaculatorius simplex, and the penis are formed from the ectoderm. The remaining organs, and the muscular covering of the ductus ejaculatorius simplex are derived from the mesoderm.

ECTODERM	MESODERM
Germ cells	Testicular coats
(Verson's Cell) ?	(Verson's Cell, or Follicula repithelium)?
Epithelium of ejaculatory duct simplex	Accessory glands
Penis	Vasa deferentia
	"Ejaculatory duct duplex"
	Muscles of all the above.
	Muscles of the ejaculatory duct simplex

The origin of the various organs, and their constituent tissues has been a problem of great importance in insect embryology. It is not the purpose of this paper to deal with the various views set forth by embryologists, but to confine the remarks to post-embryonic development.

THE NERVES.

The nerves innervating the reproductive organs are complicated and deserve special mention. Their development and changes occurring in them during the pupal and adult periods are subjects that well deserve detailed study. Some interesting features are as follows.

In the early pupal stage (Fig. 4), the seventh abdominal ganglion is closely approximated to the eighth plus tenth ganglia, near the caudal portion of the seventh abdominal sternite. Three pairs of nerves arise from the seventh ganglion; these are the seventh anterior, going to the seventh spiracles, the seventh posterior going to the body tissue, and the seventh splanchnic or sympathetic, also innervating the seventh spiracles. The posterior nerve is somewhat reduced (vestigial); this is frequently the case in Lepidoptera.

The caudal ganglion, which apparently is a fusion or condensation of the eighth, ninth and tenth ganglia, gives rise to three or four pairs of nerves. The most cephalic of these is the eighth sympathetic, which innervates the vestigial eighth spiracle. The next nerve has two branches, a long heavy one (undoubtedly the eighth anterior) passes to the eighth spiracle,

while the shorter and weaker branch (the eighth posterior) extends into the body tissue. In *Samia cecropia*, the ninth nerve arises separately from the ganglion. In ***Philosamia cynthia***, it is joined for a distance with the tenth nerve. In either case, this nerve has two branches, a long anterior branch, which extends caudad to the juncture of the seminal vesicles, and the vasa deferentia, innervating this juncture, and forming a prominent plexus there. This may be called the ***vesicular plexus*** (Vp. Fig. 4). The shorter branch is homologous with the shorter branches of the seventh and eighth nerves and is no doubt the ninth posterior. The tenth nerve is very heavy and long. It is the most interesting of all; the strong anterior branch extends caudad, to the region of the vesicular plexus, where it forms a prominent loop hole, through which the vas deferens passes; this nerve continues and gives rise to delicate branches that form what may be called the ***caudal plexus*** (Cp. Fig. 4), innervating the tissue that later becomes part of the genital appendages. From each loop hole a delicate branch extends entad, and unites with the vesicular plexus. The tenth posterior nerve passes caudad, and supplies the same tissue that the caudal plexus innervates.

What changes take place during the transformation stages have not been studied. The caudal plexus no doubt forms the nerve supply for the genitalia, and the vesicular plexus probably controls the muscles of the ducts.

HISTOLOGY OF THE TESTIS.

As previously stated, each testis consists of four chambers, or testicular tubes, combined, and surrounded by a capsule. Regardless of the form of a testis, from the histological aspect, one may consider it as consisting of two main parts, an ectodermal part of the sex cells themselves, and a mesodermal portion comprising the follicular epithelium and the various coats that make up the wall of the testis. A study of the sex cells involves observations on their origin, growth, maturation and transformation, topics that come under the heading of spermatogenesis and which are not to be treated in this paper. (Cf. Pauline Dederer, Biol. Bull., Vol. 13—*Spermatogenesis in P. cynthia*). The author wishes to deal solely with the mesodermal tissue. This may readily be considered under two headings,

the follicular epithelium and the testicular envelopes. It is simpler to treat, first, the envelopes, and then consider the epithelium, since the latter needs some explanation.

In studying the testicular chambers, one finds that their lining consists of a thin structureless membrane, which is the basement membrane (Bm.—Figs. 5, 6, 7), of the follicular epithelium; the distribution and function of the follicular epithelium will be explained later. Outside of the basement membrane is a prominent wall, which in the Lepidoptera, in general, consists of two heavy layers, an inner testicular tube coat (Ttc.—Fig. 5, 6, 7) and an outer capsular coat (Cc.—Fig. 5, 6, 7). Besides these on the periphery of the capsular coat is a thin layer of material that is apparently chitinous in nature and is probably due to the degeneration of tracheæ, which are very abundant on the testis and ramify freely over its surface.

The Testicular Tube Coat (Figs. 5, 6, 7). Of the two layers forming the wall of the testis, the inner one, or testicular tube coat, is the more interesting. The coat not only surrounds the entire testis but sends three partitions or septæ toward the hilum, forming the four chambers or testicular tubes. The cells composing this layer are very peculiar. They are of mesodermal origin, and assume the appearance of true connective tissue. They render the coat loose in its texture and fibrous in its nature. In most cases (in Lepidoptera) the cells are separated from one another, leaving large intercellular spaces in which delicate cyloplasmic fibres, from the periphery of the cells, ramify and anastomose. These two features give the coat its loose and fibrous appearance. The shape of the cells varies according to the species of insect studied. In *P. cynthia*, they are elongated and spindle shaped, in *C. promethia*, they are angular, less elongated, closer and have fewer cytoplasmic prolongations. The cytoplasm in all cases is drawn out and fibrous in nature. What is more interesting than the position of the cells as to shape and texture, is their content. They are apparently storage tissues, either for reserve materials or for products of katabolism. In the case of the Saturniids they have a prominent fat content (Fd.—Fig. 5, 6). The fat globules show very plainly and beautifully in osmic acid preparations. When stained with Mallory's C. T. stain, they stand out as brilliant orange or orange-red droplets in the pinkish cytoplasm. In *Pieris*, *Lycaena*, and species in which

the testes are colored, this coat is the repository for the pigment granules (Pg.—Fig. 7), which are believed to be waste products of urate character. Fine purplish and brown granules can be readily observes in small bits of this coat torn from the testis of *Pieris* larva and viewed in toto.

Through the interstices of this tissue, tracheæ having passed through the capsular coat, branch and ramify. These tracheæ also pass through the basement membrane into the chambers of the testis, there to resolve themselves into tracheoles which lie in close relationship with the groups of spermatocysts. This condition is to be expected since the sex cells are rapidly growing bodies, and consequently need relatively large amounts of oxygen for metabolism. Choldkovsky (1880), stated that the tracheæ never penetrate the basement membrane, and enter the follicular chambers. Koschevnikoff (1891) disproved this statement for *Apis mellifica*, and the present writer has found that each testicular chamber has small masses of tracheoles in it, which can be traced back to the tracheæ passing through the basement membrane, usually the membrane lying approximate to the septæ.

The Capsular Coat. Less interesting than the testicular tube coat is the capsular coat, surrounding the entire testis, and in some cases easily separated from its inner neighbor. Usually about the same in thickness as the inner coat, this outer layer of cells shows a marked contrast, in view of the nature of the cytoplasm and the compactness of the tissue. The layer stains poorly, but on close examination, it may be seen that the cytoplasm is very spongy and granular. The cells are usually cuboidal, and very closely placed. They may be only one layer of cells, as in *C. promethia* and *Pieris rapae*. The nuclei are usually spherical and centrally placed. There is no pigment or fat distributed in the outer coat.

As mentioned above, over the periphery of the capsular coat lies a layer of structureless material that has all evidence of being chitin or of chitinous origin. It is flakey, tough and readily stains with iron haemotoxylin, picro-fuchsin, and aniline blue. It originates probably through the degeneration of the tracheæ which are abundant over the surface of the testis. In breaking down, the chitin composing the tenidia becomes chemically changed, assumes a plastic consistency, and flows

together to make a homogeneous cover over the entire reproductive gland. This layer may readily be called the ***tracheal membrane*** (Tm., Figs. 5, 6, 7).

The Follicular Epithelium. So much for the coats of the testis. Each of the four tubes in each testis, is the male homologue of each ovarian tube. Therefore there must be a follicular epithelium. Previously it was stated that the lining of each chamber consisted of a delicate basement membrane. The basement membrane in all epithelia is on the ental periphery of the cells. Hence, the follicular epithelium must be somewhere inside of the follicular chamber. Where is it and what is its nature? That is the question that has puzzled a great number of workers on this subject.

Verson (1889) described a peculiar cell occurring in the apical region of each testicular chamber of certain insects. Other authors (La Valette St. George, Spichardt, Tischomiroff) have studied this cell (called Verson's cell, Spichardt's cell, la cellule geante, the apical cell, etc.), and have given various interpretations as to its structure and function.

Balbiani (1866) is probably the first to have noticed this peculiar structure; he considered it a mother cell for the spermatogonia. Spichardt (1886) regarded the element in question as the primordal germ cell, forming nuclei at its periphery.

Verson, in studying *Bombyx mori*, explained that this peculiar gigantic cell, produced protoplasmic extensions, fibrous in nature, that formed a complete meshwork throughout the testicular chamber. In the meshes of this net, the spermatogonia are at first scattered, then they become collected, and finally a spermatocyst or a group of germ cells surrounded by a capsule, is formed.

Verson believed, however, that the giant cell was a primordal spermatogonium. Cholodkovsky (1894) upheld the view of Verson.

Toyama (1894), in studying *Bombyx mori*, believed that there occurred, in the apical portion of each chamber, an invagination of the testicular wall, carrying with it an enlarged and specialized cell, which later lost its connection with the coat of the testis. This became the stellate cell, described by Verson. It had no genetic relationship with the spermatogonia.

LaValette St. George (1897) believed that Verson's cell was simply a transformed spermatogonium (hence, a sister and not a mother-cell to primary germ cells), giving forth prolongations that became the spermatocyst capsules.

Tichomiroff (1898) probably added the most to the studies of the apical cell. He definitely proved it to give rise to the capsules of the spermatocysts; it had no genetic relationship with the sex cells, it gave off nuclei to the capsules, and was in nature connective tissue.

Truly, to try to understand the significance of Verson's cells, from simply a study of the testes of the Lepidoptera, would be very difficult and confusing. By making comparisons with the structures of the testes of other insects, the true homology of the apical cell may be understood.

In most insects there is a thin, delicate layer of cells lining the testicular chamber, this layer, it has definitely been shown, gives rise to the spermatocyst capsule, by sending into the interior of the chambers, delicate protoplasmic prolongations that envelop groups of spermatogonia. This layer, frequently called the *cystogenous tissue*, is nothing more or less than the follicular epithelium of the testis, and comparable in all respects with the follicular epithelium of the ovarian tubes. In the Lepidoptera the state of affairs is so modified as to present an apparent absence of follicular spithelium. Comparative anatomy shows, however, that the capsular tissue in one case arises from a definite epithelium, while in the other it arises from a single enlarged apical cell. Homologizing, then, Verson's cell (Fig. 7), must be a localization and reduction of the follicular epithelium, playing the same role, i. e., that of nutrition, as does the epithelium in the ovary. Due to this special disposition of the epithelium it has lost its characteristic form and assumed a condition somewhat fibrous and similar to connective tissue.

Most investigators have missed the significance of Verson's cell, because they did not study it in stages early enough. It no doubt arises from the mesoderm, as does the follicular epithelium in the female, and only during embryonic development can its disposition be thoroughly understood.

In the larval stages, after all the spermatogonia have been gathered into spermatocysts, the apical cell disintegrates, for it is no longer needed. The capsule of each spermatocyst can readily offer all the nutriment that is needed by the growing germ cells (Fig. 8).

The Histology of the Genital Tubes.

A. VAS DEFERENS.

From each testis the vas deferens extends caudad to the seminal vesicles. In larval and early pupal stages these efferent ducts are straightish, delicate, almost invisible tubes. They look like very fine transluscent threads leading to the little papilla in the eighth segment, that later becomes the remaining portion of the genital tract. During the larval and early pupal stages, the vas deferens is uniform in diameter and possesses a prominent lumen, which is regular (i. e., without ridges) in its contour. During these stages the cellular structure is represented by Figure 9. The cells are short cylindrical or columnar, possess a rather uniformly staining cytoplasm, and show a prominent central nucleus. The chromatin of these cells occurs in irregular masses, staining prominently. These masses are rather large. The outer covering of the efferent duct may be seen as a fibrous coat that later becomes a layer of circular muscle.

As the vas deferens grows in length, it becomes convoluted; coincident with its growth in length, there is a corresponding increase in diameter. Cell division takes place very rapidly, during the mid-pupal period. In Figures 10, 11 and 12 we have represented the changes that occur during this time. At first the cells simply grow in length (Fig. 8), becoming tall-columnar; the nuclei are still very prominent and the chromatin remains in irregular masses. The cytoplasm begins to become somewhat less dense near the tip of the cells, and begins to show a vacuolated appearance. At first it was thought that this condition was an artifact due to improper fixation. Its constancy led to the abandonment of the idea. The outer coat becomes heavier.

A little later stage will show the conditions represented in Figure 11. Marked changes are beginning. Some of the cells remain stunted or are suppressed in their development. Their neighbors continue to elongate and we have at first a slight irregularity in the contour of the lumen. Parallel with this change, the cytoplasm becomes definitely vacuolate at the tips of the cells, and a change takes place in the nucleus. The chromatin begins to break up into smaller particles and these

have a tendency to round off. Whether this change has anything to do with the secretory activity of the cells the author is not prepared to say. The activity of the nucleolus was not studied. At any rate, there is a very evident change in the character of the chromatin.

Continuing a step further, we get a condition represented by Figure 12. The rapidly elongating cells crowd over one another, and we have the formation of a little nest-like mass of cells. The function of the nidus in the epithelium of the digestive tract is to replace cells, as they are cast off into the lumen. As far as was determined in the vas deferens, there is no migration of the cells into the lumen, and therefore these groups of cells should be called *pseudonidi*. The vacuolization continues, and the chromatin now appears as large granules. The nuclei remain round or oval and centrally placed.

There is a gradual, but very prominent growth of the cells in the vas deferens from now on till we reach the end of the pupal period when several changes take place rather rapidly. The pseudonidi become very prominent, and the contour of the lumen becomes markedly rigid, as figured in Fig. 16. The muscle layer has been formed and outside of it is the peritoneal membrane. The most striking feature of this stage is the structure of the epithelial cells (Fig. 12). They have become totally vacuolate, and throughout the cytoplasm occur prominent, deep staining particles that are evidently secretion droplets; where these particles come from has not been determined. The nuclei migrate to the periphery of the cell and become quite large, but the chromatin appears in very fine granules, producing a condition that does not differentiate the nucelus very well from the rest of the cell. The nuclei assume the shape of the cell. Between the muscle layer and the cells is a prominent basement membrane.

The condition of the cells at the time of the emergence of the imago may be represented by Fig. 14. The number of secretion granules is reduced, but we have in the lumen of the duct, a whitish liquid containing also an abundance of sperms. This is the seminal fluid and has been produced by the cells of vas deferens. The lower portions of the cells show a peculiar fibrous condition of the cytoplasm. This is very difficult to illustrate. The tips still show prominent vacuoles.

After copulation, all the secretion droplets have passed from the cytoplasm and this becomes still more fibrous in its nature. The vacuoles persist at the tips. (Fig. 15).

The above described metamorphosis takes place in the upper two-fifths of the efferent duct. The lower two-fifths is somewhat similar, though the lumen remains somewhat larger, and the pseudonidi are more prominent. The middle fifth of the tube remains as it was in its larval, or early pupal condition, that of a thin, uniform duct, with cells cuboidal and without pseudonidi. Secretion takes place in the upper portion and in the lower portion of the vas deferens, but not in the middle part.

B. THE SEMINAL VESICLES.

These organs may be considered as simply distensions of the vasa deferentia; their epithelia have the same growth tendency, i. e., to form pseudonidi. However, the development of the pseudonidi is not carried as far as in the case of the efferent ducts. At the cephalic and caudal ends of the vesicles, the epithelium loses its irregular character and assumes a strict columnar condition, where it graduates at one end into the epithelium of the accessory glands and at the other into that of the ejaculatory duct. The vesicles are chambers for the retention of the semen and are not centers of secretion. This latter process is localized in the vasa deferentia.

Nussbaum (1882) originally considered the vesicles, as well as the accessory glands, ejaculatory duct and penis, as derivatives of the ectoderm. Others, who also have made extensive studies of the reproductive system, believe the vesicles to be of mesodermal origin. At any rate, they are so similar to the vasa deferentia, and sufficiently unlike the other organs, to be called distentions of the former, and therefore of a mesodermal nature.

Kochevnikow (1891) found in the seminal vesicles of the honey bee, two layers of muscle, an inner circular one and an outer longitudinal. He could find none on the vasa deferentia. In the Saturniidæ, there is one layer of muscle, this is circular, and is a continuation of that found on the vas deferens (Fig. 17).

C. THE ACCESSORY GLANDS.

In the accessory glands, the cells do not become conspicuously glandular, as might be expected from the terminology of these organs.

The cells remain columnar in character and do not form pseudonidi. They do not become vacuolate, in the same sense that the cells of the vas deferens become vacuolate. The cytoplasm presents a very spongy appearance, that is present in very young cells of the glands. At first this condition might easily be taken for a general vacuolization. Comparisons with other types of cells show that it is quite different, however. Many authors believe that there is a secretion of these organs, and that the secretion causes the formation of spermatophores. This may be true. Secretion is not as evident as in the cells of the glandular part of the vas deferens, and proceeds in a different manner.

The accessory glands differ from the organs previously discussed, in the possession of a single longitudinal layer of muscle. This in early stages of the development of the reproductive system may be continuous with the muscle of the upper end of the ejaculatory duct. This has not been definitely determined.

Koschevnikow (1891) found three layers of muscle in the glands of *Apis;* an inner longitudinal layer which may not extend the entire length of the tubes, a central circular and an outer longitudinal.

In some insects the accessory glands may actually be ectodermal in origin. Many authors do not believe so, however. If they were ectodermal, there would be a tendency toward the formation of an intima, which, as far as has been determined, does not exist in them.

D. THE EJACULATORY DUCT.

As stated previously, the ejaculatory duct consists of two parts, at least it is so considered by several authors, prominent among whom is Schroeder. The upper part is divided into two tubes, the ***ductus ejaculatorius duplex*** (of Schroeder), which are short and connect at their cephalic end with the seminal vesicles. These tubes are probably simply caudal prolonga-

tions of the seminal vesicles. Their epithelium is somewhat similar to that of the vesicles and their musculature is the same.

Passing caudad to the union of this so-called ductus ejaculatorius duplex, we find we have a change in the musculature, which now takes on a longitudinal course. (Fig. 19). For quite a distance the epithelium retains its uniform columnar appearance. The longitudinal muscle is characteristic of the *ductus ejaculatorius simplex*, which is the caudal portion leading to the base of the penis. Undoubtedly this duct is ectodermal in origin. It is an invagination of the hypodermis and bears, for more than one-fifth of its length, a prominent intima. Above the caudal fifth the chitinous lining becomes thin and indistinct and is wanting at the juncture of the ductus ejaculatorius simplex and "duplex."

The longitudinal muscle, characteristic of the upper end of the single tube, has added to it, a prominent layer of circular muscle about half way along the duct (Fig. 20). The circular muscle appears outside of the longitudinal. Toward the caudal extremity the musculature becomes very uneven and very prominent, till about the so-called "bulbus ejaculatorius," it is very heavy, and interwoven. A third, outer longitudinal layer is added (Fig. 21). Koschevnikow could not find muscle in the ejaculatory duct of *Apis mellifica*. This seems very strange, in view of the function of this organ.

The epithelium of the ejaculatory duct goes through a metamorphosis comparable with that of the vasa deferentia, i. e., it forms pseudonidi, but these are covered over with the intima. In the so-called "ejaculatory bulb," the epithelium is actually folded, assuming the appearance of the epithelium of the proventriculus.

What by some authors is called the ejaculatory bulb is in reality a continuation of the simplex duct, with abundant muscle, with no enlargement, but a reduction of its lumen. Its function is to force the seminal fluid through the chitinous penis.

CONCLUSION.

(1) The Saturniid testis belongs to Chlodkovsky's second (larval) type, consisting of four testicular tubes combined in a common capsule.

(2) The greatest changes take place during the pupal stage.

(3) The inner coat, of the testis and not the outer one, is fatty in nature.

(4) Verson's cell is a modified follicular epithelium, giving rise to the spermatocyst capsules.

(5) The cells of the vas deferens are the source of the seminal fluid, the accessory glands and seminal vesicles are storehouses.

(6) The accessory glands have a longitudinal layer of muscle; the seminal vesicles a circular layer, the upper end of the ejaculatory duct has longitudinal muscles, the lower portion has added a circular and an outer longitudinal layer as well.

(7) There is a definite and complicated innervation of the internal genital organs.

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EXPLANATION OF PLATES

PLATE X.

Fig. 1. A, B, C, D. Chlodkovsky's four types of Lepidopterous testes. A, *Hepialus;* B, *Saturnia;* C, *Lycaena;* D, *Pieris*. All diagramatic. E, adult genital system in Samia cecropia, semi-diagramatic. × 8.

Fig. 2. Sagittal section of testis, showing chambers, hilum, and two coats. Diagramatic.

Fig. 3. Detail of hilum of testis. Note the continuity of the basement membrane of the chamber with that of the epithelium of the vas deferens. Camera lucida drawing.

PLATE XI.

Fig. 4. The relation of the nervous and reproductive systems in an early pupal stage of *Philosamia cynthia*.

Fig. 5. Detail of coats of testis of *Callosamia promethia*.

Fig. 6. Detail of coats of testis of *Philosamia cynthia*.

Fig. 7. Detail of apical region of a chamber in the testis of *Pieris rapæ*, showing Verson's cell giving rise to spermatocyst capsules. The black particles in the cytoplasm of the apical cell are portions of the parent nucleus, (probably formed by amitosis) migrating to the fibrous prolongations to become the nuclei of the spermatocyst capsule.

Fig. 8. Adult (sperm stage) spermatocyst.

PLATE XII.

Figs. 9–15. Growth of the epithelium of vas deferens from larval (or early pupal) stage (9) to the late pupa, (13) when the cytoplasm contains secretion droplets, to the adult stage (15), when the secretion droplets disappear and the tips of the cells vacuolize.

Fig. 16. Trans-section of vas deferens, showing general contour of epithelium.

Fig. 17. Epithelium of upper end of seminal vesicle.

Fig. 18. Epithelium of accessory glands.

Fig. 19. A, Trans-section of ejaculatory duct, near its union with the "ductus ejaculatorius duplex." B, Epithelium of same.

Fig. 20. Trans-section of ejaculatory duct, midway along its length. Note the addition of circular muscle.

Fig. 21. Trans-section of ejaculatory duct near ejaculatory "bulb." Note the addition of muscles and the presence of an intima.

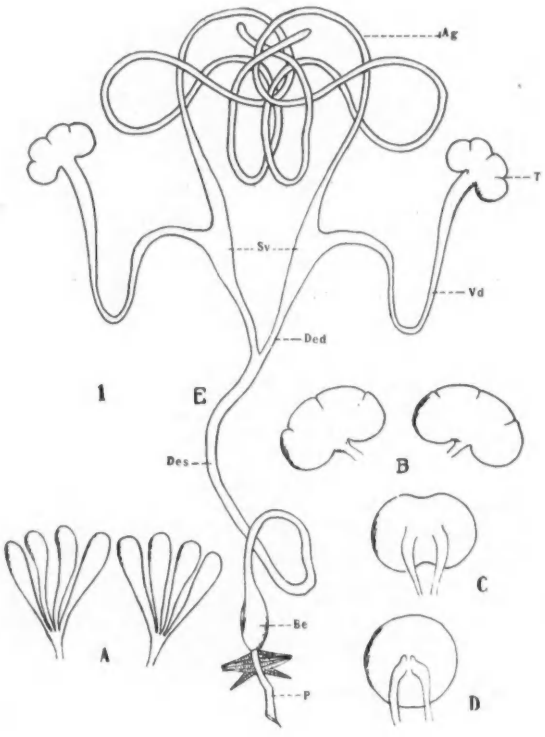
Each scale line is equivalent to 100 micra.

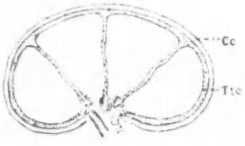
ABBREVIATIONS.

Ac.—Apical cell (Verson's cell)—Follicular epithelium.
Ag.—Accessory glands.
Be.—Ejaculatory "bulb."
Bm.—Basement membrane.
Cc.—Capsular coat.
Cm.—Circular muscles.
Cp.—Caudal plexus.
Ded.—"Duetus ejaculatorius duplex."
Des.—Ductus ejaculatorious simplex.
Epi.—Epithelium (of genital ducts).
Fd.—Fat droplets.
I.—Intima.
Lm.—Longitudinal muscles.
Lvd.—Lumen of vas deferens.
P.—Penis.
Pg.—Pigment granules.
Sd.—Secretion droplets.
Sp.—Spiracle.
Spc.—Spermatocyst capsule (follicular epithelium).
Spg.—Spermatogonia.
Spn.—Nucleus of spermatocyst capsule.
Spv.—Vestigial spiracle.
Sv.—Seminal vesicles.
T.—Testis.
Tm.—Tracheal membrane.
Tr.—Tracheæ.
Ttc.—Testicular tube coat.
Vd.—Vas deferens.
Vp.—Vesicular plexus.

FOR FIG. 4.

7, 8, 9, 10—Abdominal nerves.
A—Anterior.
P—Posterior.
S—Sympathetic.





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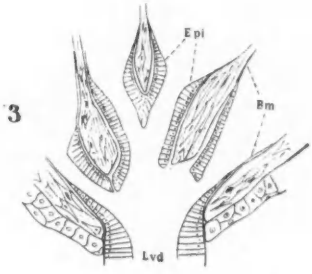

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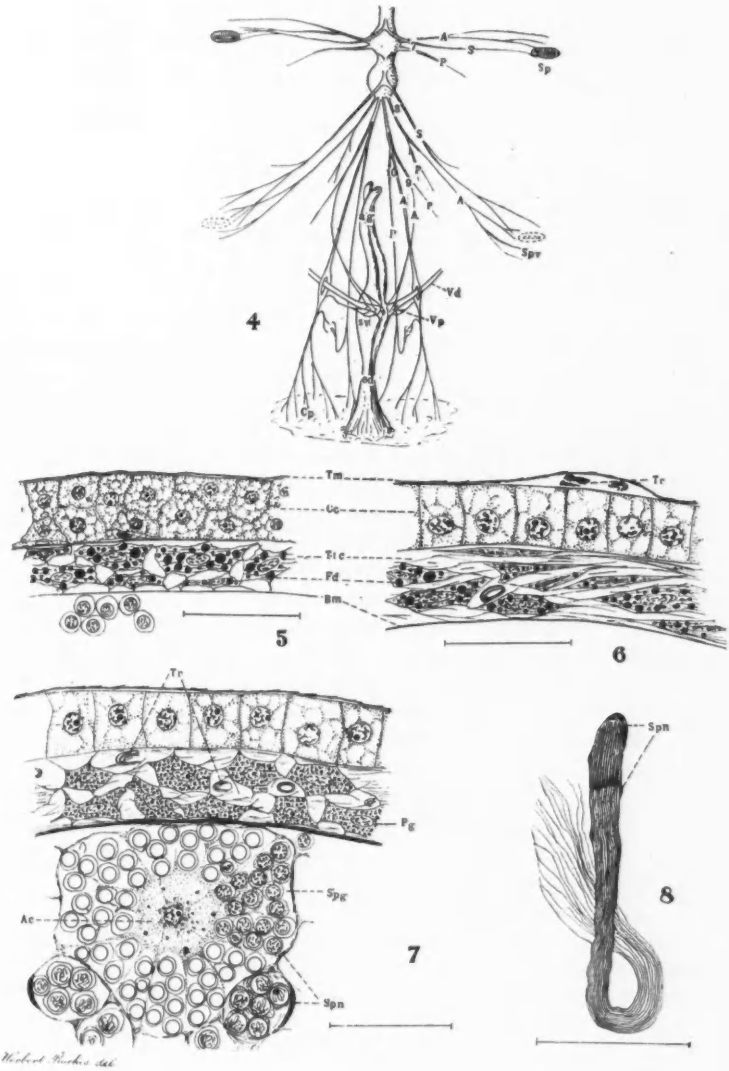

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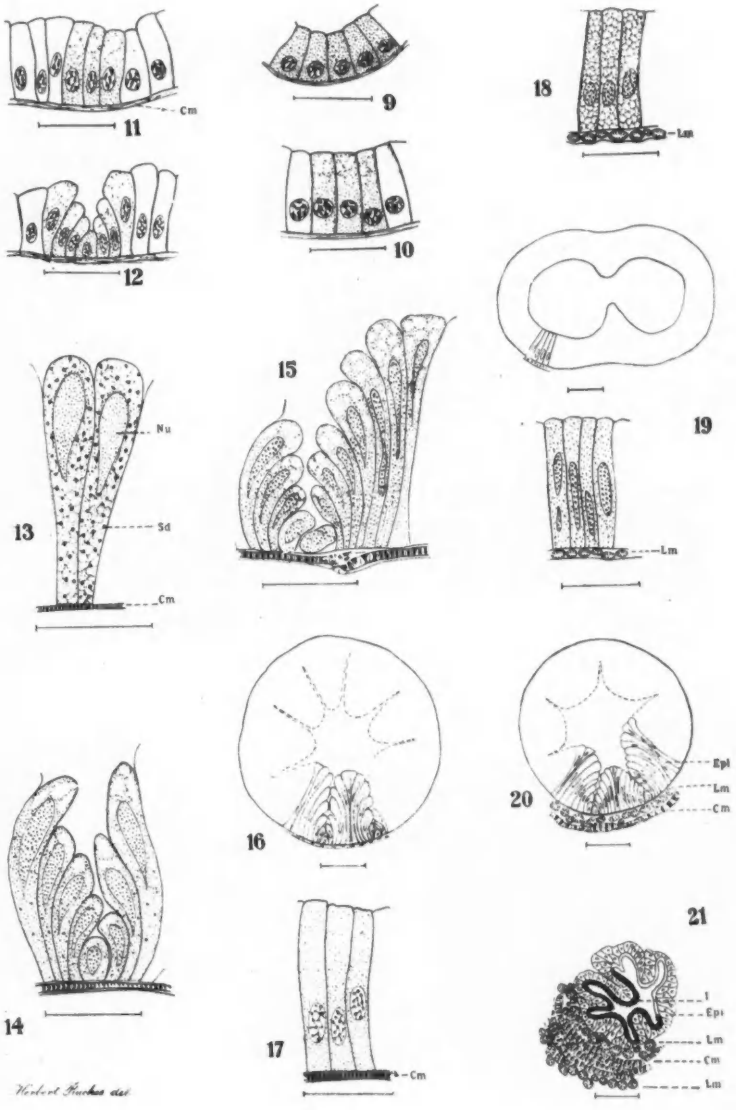

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THE AQUATIC ADAPTATIONS OF PYRAUSTA PENITALIS GRT. (LEPIDOPTERA).*

PAUL S. WELCH.

INTRODUCTION.

The unique and ingenious methods whereby aquatic animals have solved their problems of maintenance are always interesting, particularly in a group having an immediate terrestrial ancestry, as is the case with aquatic insects. It is a well-known fact that among insects all graduations between the terrestrial and aquatic species can be found, often within one family. Similar transitions are now known to exist within a single species. Some of these transitional forms, while retaining certain terrestrial habits and potentialities, have progressed far in the development of aquatic adaptations and solve the problems of the new environment with remarkable ease. While Lepidoptera are preëminently terrestrial, there exists a very small, heterogeneous group of species which presents aquatic adaptations of peculiar interest. The climax in aquatic adjustment for this group is probably represented by the gilled caterpillars of *Nymphula* (Welch, 1916). *Pyrausta penitalis* Grt., on which this paper is based, presents a striking case, not only of transition from terrestrial to aquatic habit, but also of a development of physiological adaptations which parallel closely those appearing in certain other unrelated Lepidoptera (Welch, 1914).

The field data used in this paper were secured during the summer of 1917, while the writer was a member of the Ohio State University Lake Laboratory staff. In the protected coves of Sandusky Bay, Lake Erie, particularly Beimiller's Cove, *Nelumbo lutea* grows abundantly and during July, 1917, there appeared upon this plant large numbers of the caterpillars and pupæ of *Pyrusta penitalis*. The abundance of material and the constant presence of practically all degrees of development made possible a wide range of observations in a relatively short time. Since the writer has spent but the one season at

*Contribution from the Zoological Laboratory of the University of Michigan.

the Lake Laboratory, this report is incomplete in many respects, but the data contained herein are presented with the hope that they may serve as an added basis for future work.

Several papers already published contain information on this insect, but in all of them the data are meager and fragmentary, the sum total representing a very incomplete account. Smith (1890a; 1890b) discussed it under the name *Botis nelumbialis*, giving account of the imago, mature larva, and pupa. Later, Hart (1895) described in more detail the stages of the life-history and presented a few biological features of the larva and pupa. Recently, Chittenden (1918) recorded some interesting terrestrial activities of this species.

Coquillett (1880) described what he thought to be the larva of "Botis penitalis," stating that it fed on Indian hemp (*Apocynum cannabinum*). Chittenden (1918, p. 454), however, points out a certain disagreement of Coquillett's description with the true larva of *penitalis* and suggests the probability that some other species was under observation. Dr. J. McDunnough, in a recent letter to the writer, confirms the suspected error in this record and states that the *Apocynum* feeder is the allied *futilalis* Led. and that he has bred the latter in abundance at Decatur, Illinois.

The writer wishes to express his indebtedness to Dr. J. McDunnough for confirmation of the identification of this species.

THE LIFE-CYCLE.

In the above-mentioned papers are found accounts of the full-grown larva, the pupa, and the imago and further mention is not required here. However, the eggs and place of oviposition have heretofore remained undescribed. The writer, after much searching, finally found, on July 28, a single egg-mass on the upper side of a *Nelumbo* leaf, which, when brought into the laboratory and kept in an aquarium yielded larvæ that were unquestionably those of *penitalis*. This mass was amber-colored, and approximately circular in contour, having a diameter of 3 mm. About sixty eggs were present, surrounded by an amber-colored matrix, and closely set together. On hatching, the egg-shells lost the amber color and assumed a dirty grey appearance. All of the eggs developed normally and larvæ emerged, but since the exact time of the oviposition

of the mass was unknown, the length of the egg-stage could not be determined. The young larvæ, at the time of hatching, were about 1.5 mm. long. They immediately began feeding upon the leaf in the vicinity of the egg-mass, consuming the upper surface in the characteristic manner. The surface webbing, described later, appeared very soon, subsequent development and activities continuing in the fashion normal for the species.

The difficulty of finding the egg-masses is quite puzzling since the writer examined hundreds of *Nelumbo* leaves and the amber color of the egg-mass against the green background of the leaf, if that be the usual place of oviposition, should make detection rather easy. Furthermore, the writer observed dozens of leaves each bearing very small larvæ which, it would seem, must have emerged from eggs deposited very near by, but no indications of old egg-masses were detected.

Chittenden found a considerable number of these larvæ boring into the canes of raspberries and likewise, to some extent, in the stalks of corn. However, he states (p. 455), that "there is no evidence that the species feeds on either healthy corn or raspberry, although it feeds on the pith to a considerable extent, but on the contrary develops chiefly upon lotus and other aquatic or semiaquatic plants and enters cornstalks and the cut ends of raspberry canes chiefly as a retreat for passing the winter and for subsequent transformation." This statement is not entirely clear. It seems to imply that corn and raspberry may not be affected unless in some unhealthy condition. It also appears to suggest that these larvæ pass their early development in aquatic situations and then some of them migrate to certain terrestrial plants in order to find a hibernation place. Chittenden has tried to formulate "an approximate life history" from the fragmentary bits of available information and suggested that the larvæ constitute the hibernation stage; that the adults begin emerging in March; that larvæ appear in due course of time and feed until late in August when they complete their growth, seek a convenient winter retreat and hibernate. Such a statement suggests only one generation per year.

Certain observations of the writer do not seem to corroborate the above-mentioned inferences. It was not possible to determine the hibernation stage and it may be that some of the larvæ, in late autumn, do migrate to shore and find hibernation

quarters in connection with other plants. However, *Nelumbo* often occurs somewhat remote from shore and while, as will be shown later, these larvæ are efficient swimmers, it seems rather doubtful if such is the only method. Since pupæ are found in the upper end of the *Nelumbo* petioles during the summer, the writer is inclined to suspect that hibernation, in the aquatic situations, may occur as pupæ in cocoons within the old food plants. Circumstantial evidence also seems to indicate more than one generation per year. During the first week in July, larvæ of all sizes as well as pupæ were found and from that time to early August, when the writer's observations ceased, adults were emerging continually from the *Nelumbo* petioles. Quite a number of such pupæ were reared in aquaria in the laboratory. Since these immature forms occurred in connection with the fresh leaves and petioles and were of all sizes and ages, the evidence seems clear that they were not overwintering individuals. Furthermore, the emergence of adults throughout the most of July (and possibly to some extent later) and the finding of eggs on July 28th, suggests a midsummer brood. Therefore, the writer is inclined to believe that in the region of Lake Erie the species is at least double-brooded and that hibernation may occur in connection with the aquatic food-plants.

ADAPTATIONS TO AQUATIC SURROUNDINGS.

The chief aquatic adaptations manifested in this species are related to the problems of food-getting, locomotion, and respiration—problems which are always of vital importance in the adjustment of an animal of terrestrial origin and organization to partial or complete aquatic life. While this species thrives under the conditions of its aquatic surroundings, it is interesting to note that the complete, original terrestrial organization has apparently been retained, that no structural features of aquatic importance have appeared, and that the adjustments to the water are very largely, if not entirely, physiological, consisting of habits and activities which result in the favorable solution of the problems involved. The physiological adjustments of this species to water offer a very close and interesting parallel to those of *Bellura melanopyga* Grote (Welch, 1914) a species which is remote from *Pyrausta penitalis* in kinship, but which has solved its major problems

of locomotion, nutrition, protection, and respiration not by structural developments, but by modified activities remarkably similar to those of *P. penitalis*.

FEEDING HABITS.

Food Plants.—In the Sandusky Bay region, *P. penitalis* was found only on *Nelumbo lutea*. Other plants in the same habitats and on nearby shores were examined from time to time, but appeared to be unaffected by this insect. However, it is evidently a general feeder, since other writers have reported it on *Polygonum incarnatum*, *Polygonum hydropiperoides*, *Eupatorium* (species not given), and *Nelumbo nucifera* ("Egyptian lotus"). An erroneous record of *Apocynum cannibinum* was mentioned on a foregoing page.

Leaf-feeding Period.—Two well-defined periods can be recognized in the feeding activities of the larvæ, (1) an early one, the *leaf-feeding period*, and (2) a later period, the *petiole period*. These two periods were given bare mention by Smith (1890a) and Hart (1896, pp. 180-181), but the details and adaptations have not been described.

After hatching, the young larvæ feed upon the outer surface of the *Nelumbo* leaf, removing the upper epidermis and a considerable part of the underlying chlorophyll-bearing tissue. The feeding areas are irregular and vary in size, depending upon the amount of feeding done. They often become confluent, forming large irregular areas. When first made, they are light greenish, but soon change to brown and in time the whole leaf, if heavily infested, assumes that color.

While any part of the upper leaf surface is subject to attack, feeding at the periphery differs, in certain distinct respects, from that within the periphery, and likewise involves distinct differences in accompanying adaptations. These activities will be described in the reverse order of mention.

Leaves bearing young larvæ almost invariably show, when examined critically, numerous, very fine strands of silk all over the upper surface, marking the routes of the wandering larvæ. This apparent wastefulness in silk production is perhaps the first form of aquatic adaptation to appear in the life-cycle since the silken thread continually anchors the tiny larva to the leaf during its search for an appropriate feeding place and aids in preventing it being washed off the leaf by waves or other surface

disturbances. When active feeding begins, the silk formation becomes a more noticeable and important feature. Feeding areas are surface excavations, usually with a depth greater than the diameter of the caterpillar, across which is spun a fine, somewhat substantial silk web, and under which the larva works and rests. Frequently, the threads are tied across from one radiating leaf vein to the adjacent one with sufficient tension to pull them slightly towards each other, thus producing a depression beneath the web and providing a retreat for the larva. These nets are of varying extent, but since they are a constant accompanying feature of surface feeding, an attempt was made to determine their significance. That they play some real part in the life of the larvæ is manifested by the fact that while individuals occasionally leave the web-covered tunnels for a certain amount of wandering, they almost invariably return to the original ones or preëmpt others which happen to be empty. Since the leaves of *Nelumbo* rest upon the surface of the water, wave-action, even of a slight degree, often inundates them and, unless protected in some way, the young caterpillars would be constantly exposed to the serious menace of being washed off. A series of experiments showed that the silk webbing constitutes an efficient safeguard against dislodgment by waves. When the larvæ are ensconced under these webs, a vigorous dragging and threshing of the leaf through the water in a manner more severe than the effect of a heavy storm in the protected coves, fails in most cases, to wash them away. Possibly, these webs may serve, also, as a partial protection against certain enemies and excessive light, but according to the evidence at hand, its chief rôle is that of an important adaptation to an ever present feature of the aquatic environment.

Peripheral feeding and accompanying silk formation differ in character from the above-described activities. For varying distances the thin edge of the leaf is folded over and tied by strands of silk which extend from the upturned edge to the upper leaf surface. Varying amounts of silk are used in this activity. Instances were observed where the web was thick and brownish, resembling, to some extent, a sort of cocoon. Often, however, it is a fine, thin, dainty webbing through which the larvæ are plainly visible. Feeding invariably occurs under these webs. Peripheral feeding is a very common habit nearly every infested

leaf showing evidence of it, and occasional leaves are affected only in this way. Sometimes, the entire margin is turned up and tied over. Funnels formed in this fashion are effective retreats and provide efficiently against the larvæ being washed away by wave-action. Sometimes, the turned over edge collects a small quantity of water, and the larvæ may be partly submerged for a time, although no inconvenience seems to be suffered. Since complete filling of the peripheral tunnels with water is possible, the larvæ may, in such an emergency, escape drowning by migration to the petiole junction—a region more elevated, normally, than the margins and more likely to be free from water. The rare occurrence of pupæ in these upturned margins will be mentioned later. Whether the leaf-feeding period is confined to certain instars was not determined. Exuviæ from small larvæ were frequently seen, particularly under the webbings. Field observations on hundreds of larvæ showed that the surface feeders include individuals up to about 14 mm. in length. It thus appears that more than one instar are included in this period.

Petiole Period.—When a certain growth is attained (apparently about 14 mm.), a distinct change in the feeding habit occurs. Surface feeding under webbings is abandoned and the larva begins to tunnel lengthwise into the upper end of the petiole, boring through from the upper surface. By what means the petiole-leaf junction is located with striking exactness is a matter of conjecture. Instances were observed in which wandering larvæ encountered an uninfested leaf, located immediately the petiole junction and began excavation. Sometimes, the larva bores into one of the chief veins of the leaf, tunneling down it to the petiole. Occasional failure to make exact connection with the end of the petiole, resulting merely in a hole through the leaf, is compensated for by constructing an entrance into the side of the petiole just beneath the leaf. A surface net is often constructed over the petiole-leaf junction beneath which the larva works in forming the burrow. When disturbed, it may leave this shelter, wander about over the leaf for a time, later returning to the web or seeking refuge under old nets at the periphery.

The burrow varies somewhat but usually the length is about 23-70 mm. and the diameter a little greater than that of the larva itself. Its entrance is often surrounded by an accumula-

tion of brownish excrement, the burrow being kept comparatively free from such accumulations. Although most, if not all, of the material excavated from the petiole is passed through the digestive tract of the larva, the principal function of the burrow is other than that of a place to feed since the total length does not exceed double that of the full-grown larva—a condition which would not prevail if it were a true feeding burrow, as in the case of *Bellura melanopyga* (Welch, 1914, p. 102) where burrow length increases with occupancy. Not only is the tunnel always short, but also, once formed, it becomes brown inside, and thereafter shows no evidence of further excavation.

After a burrow long enough to contain the whole larva is constructed, the caterpillar turns about and feeds mostly on the upper surface of the leaf just outside the entrance. Larvæ are frequently observed on the upper leaf surface with only one or two posterior body segments remaining in the burrow. A very slight disturbance, however, causes rapid return. Feeding in this position usually results in elongate surface etchings which radiate from the petiole junction. Sometimes the surface within easy reach from the burrow is completely denuded. It thus appears that the chief function of the burrow is to afford a safe retreat from which surface feeding may be accomplished. This accounts for the fact that an examination of a large number of inhabited petioles showed the head of the larva almost invariably directed towards the leaf. As will appear later, the burrow serves also as a pupation chamber.

At no time was more than one larva found in a burrow, the same being true for the pupæ. Occasionally, a nearly mature individual may, for some unknown reason, desert its burrow and wander about over the *Nelumbo* leaves, ultimately constructing a new burrow in some uninfested leaf or else preëmpting an already formed one which it may chance to find unoccupied. Instances were observed where such a wandering larva attempted to enter a burrow already inhabited, whereupon the occupant and the invader engaged in active combat at the entrance, interlocking mandibles, twisting heads, and pushing each other about in a vigorous manner, until the former succeeded in repulsing the latter, or until the invader forced an entrance, displacing the original occupant.

Effect on Food-plant.—In proportion to the numbers of larvæ present, the leaf of the food-plant loses its chlorophyll-

bearing tissue and ultimately shows signs of deterioration. The upper surface shows discoloration, loses its waterproof character, and, in the Sandusky Bay region, usually becomes covered with chironomid (Diptera) larvæ, which form their mud cases all over the exposed surface. Burrow construction partly severs the connection of the leaf with the rootstalk and often results in the ultimate deterioration of the floating part, even in the absence of surface feeding. Since the work of a single larva may lead to leaf deterioration and since it is known that, when present, the buds and seed-capsules are also attacked, it is evident that *P. penitalis* is a serious enemy of *Nelumbo*. The ability of the older larvæ to migrate from leaf to leaf, as described later, also increases their menace to the food-plant.

LOCOMOTION.

Crawling.—Change of position on the food-plant is accomplished by the ordinary methods of crawling. These larvæ are sufficiently active to enable them, where *Nelumbo* leaves are contiguous, to wander widely from the hatching place.

Swimming.—One of the noteworthy adjustments to the aquatic surroundings appears in a well-developed form of surface swimming. Larvæ removed from petiole tunnels and dropped lightly on the water remain supported on the surface. After a few initial squirming movements, active swimming is begun and, as long as nothing interferes with the surface position of the larva, progression is distinctly efficient. Swimming movements consist of an alternate, horizontal, whip-like motion of the posterior half of the body. The sequence of motions is as follows: The posterior end of the body is flexed horizontally on one side into a position in which the caudal end is directed cephalad; then, with a strong, quick sweep, as if released from considerable lateral tension, it returns to the normal position, stopping there for a brief interval; then a similar flexure and return is made on the opposite side. This whip-like motion, first on one side and then on the other, resembles the action of a straight steel spring fixed at one end, bent laterally, suddenly released and stopped at the median position without further vibration; then bent and released on the opposite side. This strong, vigorous return of the posterior end to its normal position constitutes an effective stroke against the water and propels the animal at a goodly rate. So strong

is this lateral beat against the water that it swings the anterior end of the larva in the opposite direction, the succeeding stroke swinging it in the reverse direction, thus making the course described by the head a distinct zig-zag, characterized by abrupt rhythmic changes in the lines of progression. While the swimming activities of this larva resemble in many respects, those of the larva of *Bellura melanopyga* (Welch, 1914, pp. 110-112), there is a distinct difference in the swimming movements, since in the latter they are of the graceful sinuous type and lack entirely the jerky character of the former.

As mentioned above, these larvæ swim in a surface depression. They have an integument which resists wetting and enables them to utilize the surface film, but experiments showed that if these caterpillars break entirely through it they sink slowly, performing in vain the swimming movements described above. They seem to have no ability whatever to swim in water and individuals which become completely submerged ultimately go to the bottom. The fate of such larvæ is not known. It is possible that some may return to the surface by crawling up the stems and petioles of floating and emergent vegetation, since experiments showed that they can withstand continued submergence for at least one and one-half hours.

Sometimes a larva gets inverted on the surface film and has great difficulty in righting itself. The swimming activities are continued, however, in the regular way, progress being made until contact with some plant or floating object enables the caterpillar to regain its normal position.

Ordinarily, larvæ seem somewhat unwilling to leave a supporting leaf and take to water, but when sufficiently disturbed they will voluntarily do so. No doubt new retreats and new feeding surfaces are sought in that way also.

RESPIRATION.

Larval Stages.—As mentioned before, the larva has developed no structural adaptations in connection with its aquatic relations. So far as respiration is concerned, it is a typical air-breather and requires direct exposure to the atmosphere. Throughout the whole larval existence, protection against complete submergence is afforded. Certain features of the food-plant aid materially in accomplishing this end. The exposed surface of the leaf is waterproof, due, according to

Pond (1918, p. 181), to many very delicate hairs which enclose an envelope of air, preventing the water from actually touching the epidermis. Unless the leaf has suffered considerable damage, water thrown upon its upper surface rolls off immediately in silvery masses. Some water is occasionally trapped on the surface by upturned margins, but it also fails to wet the surface, and rolls off at the first opportunity. Furthermore, the region of the petiole junction is normally somewhat higher than the surrounding area, thus producing a sloping surface which easily sheds off any water falling upon it. These two features of the plant are effective not only in keeping the exposed surface above water, but in keeping water away from the burrow. Surface feeding ultimately makes the leaf untenable by the removal of the waterproofing provision and the subsequent wetting and submergence of the surface. Except for short accidental periods of submergence, contact of these larvæ with the water is very slight and offers no obstacle to their obligatory holopneustic respiration. Surface swimming also permits dissemination without interference with the usual respiration activities.

All of the burrows which came under the writer's observation seemed remarkably free from water, in spite of the fact that at least a part of each fully constructed burrow is below the water-level outside. In contrast to the larva of ***Bellura melanopyga*** which lives in a water filled burrow in the petiole of the yellow waterlily and secures oxygen only when at the top, the larva of *P. penitalis* seems to occupy a burrow which is free of standing water and ordinary spiracular respiration is possible at all times.

Pupal Stage.—Although the exact oxygen demands of the pupa are not known, it is fair to assume that they differ but little from other similar pupæ formed in terrestrial environments since the structural features of the respiratory system are the same. Continued submergence of a pupa removed from its silken covering results fatally, indicating that it also must have a certain protection from water. In connection with the field observations, the writer examined many cocoons, none of which contained water. In fact, the pupa appears to be well provided for in this regard. When the full-grown larva begins preparations for pupation, the first activity is the formation of cream-colored, circular, concavo-convex, very closely

woven silk cap or plug at the upper end of the tunnel, completely closing it. This plug is quite firm in texture and has a thickness of about 0.7–0.8 mm. over most of its area. At the periphery, where it makes contact with the side of the burrow, it is reduced in thickness to an extremely fine membrane, thus providing for the emergence of the imago. The greater part of the burrow is then lined with a strong, silken cocoon, in the upper end of which the pupa is formed. This cocoon is connected with the above-mentioned cap by means of a vertical curtain of silk. The closing plug and complete cocoon seem to be effective in excluding the water and make it possible for this type of pupa to successfully pass its quiescent period in a position slightly below the water line. That this is an aquatic adaptation is indicated by Chittenden's observation (1918, p. 456), that under the terrestrial conditions of raspberry plants a "small amount of silk is used in the construction of these hibernating chambers, and a little is usually to be found at either end"—a description which in no way applies to the same activities of the larva in the *Nelumbo* petiole. The versatility of this larva in becoming adjusted to different surroundings is manifested by the fact that the writer found a few instances of pupation in the rolled up edges of the *Nelumbo* leaf—instances in which a strong, silken cocoon was formed, but no hint of any special features such as the lid-like cap to the petiole burrow. Nothing can be stated at present concerning the nature of the stimuli or sets of stimuli which are operative in impelling the larva to produce an entirely different cocoon for each of the three known pupation conditions, viz., the petiole burrow, the rolled leaf margin, and the stems of certain terrestrial plants. The fact, however, certainly emphasized the special adjustments which have been developed in connection with the aquatic conditions and which have been superimposed upon a persistent ancestral habit.

While it seems evident that the closing cap at the entrance to the tunnel and the underlying, strong, silken cocoon provide a certain protection against drowning, they are not sufficient to safeguard the pupa from another danger—the larvæ of its own species. It often happens that some larva, wandering on the *Nelumbo* leaves, eats away the closing cap of a pupal chamber, penetrates the upper end of the cocoon, destroys the upper portion of the pupa, and ensconces itself in the re-opened

tunnel. Whether the tissues of the pupa were actually used as food or whether the tunnel making instinct of the invading larva caused it to excavate anything which obstructed passage was not determined.

SUMMARY.

1. *Pyrausta penitalis* Grt. (Pyralidæ) occurs abundantly in certain protected situations about Lake Erie in connection with its favorite food plant, *Nelumbo lutea*. It belongs to that extremely limited but interesting, heterogeneous group of Lepidoptera, which has made progress in the development of aquatic adjustments.

2. The life-cycle is imperfectly known. Evidence indicates at least two generations per year. Larvæ and pupæ develop in connection with *Nelumbo*, and eggs, described for the first time, occur on the same plant. Previous writers report relations not only to certain other aquatic plants, but also to two strictly terrestrial ones. Dependable data on the hibernation are lacking.

3. While successfully adjusted to aquatic surroundings, this species has retained the ability to utilize terrestrial conditions, at least to a limited extent. The complete, original, terrestrial organization has apparently been retained also, so that the aquatic adaptations manifested are very largely, if not exclusively, physiological.

4. Surface feeding by young larvæ occurs under silken webs so constructed as to afford adequate protection against dislodgment by wave-action, an ever present menace. The upturned, silk bound margins of the leaf function similarly. Older larvæ construct short petiole tunnels which function only as places for retreat and protection, from which a different type of surface feeding is performed.

5. The older larvæ possess a well-developed, efficient form of surface swimming consisting of an alternate, horizontal, whip-like motion of the posterior portion of the body. They have, however, no ability to swim under the surface and, when completely submerged, sink to the bottom.

6. While an older larva can withstand constant submergence for about one and one-half hours, its typical holopneustic tracheation necessitates access to the atmosphere. Protection from prolonged submergence is provided in part by the water-

proof character of the upper epidermis of the *Nelumbo* leaf and the elevated position of the petiole junction. Surface swimming permits dissemination without serious interference with normal respiration.

7. Pupation occurs in the petiole burrow below the water-level outside and since submergence is fatal, protection is provided not only by the walls of the petiole and the formation of a firm, silken cocoon, but also by the construction of a special closing device—a cream-colored, circular, concavo-convex cap—at the top of the tunnel excluding the water, but providing for the ultimate emergence of the adult. Occasional pupation in the upturned leaf margin is accompanied only by simple cocoon formation, but pupation in terrestrial plants, according to certain writers, appears to be nearly devoid of such provision.

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CHARIESTERUS AND ITS NEOTROPICAL RELATIVES (COREIDÆ HETEROPTERA).

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The Squash-bug family contains an unusually large proportion of insects of bizarre form and possessing strange structures. Expanded or curved tibiæ, swollen and spinose femors, and flattened or clavate antennal joints seem to be the rule rather than the exception.

Among the more modest of the peculiar species are those of the tribe Chariesterini, a group whose members possess a flattened spatulate expansion of the third antennal segment and obliquely truncate, usually spinose, antenniferous tubercles. *Chariesterus antennator*, the most northern member of the tribe, is well known from New Jersey and Iowa to the Gulf of Mexico. A new species from California is described below, whose peculiarly shaped pronotum makes it one of the most remarkable of the Coreidæ.

The tribe is confined to the western hemisphere and includes three genera: Plapigus, Staluptus, and Chariesterus.

Plapigus now contains seven or eight described species, all South American except *circumcinctus* Stal from Mexico. This is a black form, with margins of pronotum, corium, and abdomen flavescent, a distinct callosity behind the eye, tibiæ with testaceous annulus, and expansion of third antennal segment longer than broad. The internal angle of each antenniferous tubercle is acute, and the first segment of the antennæ subclavate; the pronotal margins are entire, and the humeri each armed with a single long slender spine.

Staluptus marginalis Burmeister, according to the original description, is black, with unarmed posterior femora, which are fulvous at base, scarcely dilated third antennal segment, and brown venter and femora. It was described from Mexico.

The species of *Chariesterus*, seven in number, are more widely distributed than other members of the tribe, ranging throughout both continents. In this genus the first antennal segment is parallel-sided, though sometimes slightly broader

toward the tip. The callosity behind the eye, instead of being wanting, as Stal states, is merely usually smooth without acute points, although a few specimens of *C. antennator* from Kansas and Nebraska are at hand in which this tubercle is distinctly muricate.

The following synopsis is based on specimens in the collection of Dr. E. D. Ball, Mr. William J. Gerhard, of Chicago; Mr. H. G. Barber, Mr. Carl J. Drake, the Wisconsin Agricultural Experiment Station, and the Milwaukee Museum, except for *C. armatus* and *C. albiventris*, for whose positions reliance was placed on descriptions. The distribution of each species is indicated in the synopsis for the sake of brevity.

KEY TO THE SPECIES OF *Chariesterus*.

a. Antennæ dilated equally on both sides of third segment.
  b. Dilation of third antennal segment only three-tenths as wide as long; legs and antennæ ferrugineous; size 9 x 1.2 mm. (Antilles). *gracilicornis* Stal.
  bb. Dilation of third antennal segment at least four-tenths as wide as segment is long; legs and antennæ black; body above brown, below albo-farinaceous; length 11 mm. (Texas and Mexico). *albiventris* Burm.

aa. Antennæ with third segment more angularly dilated on lower side; length over 10 mm.
  b. Lateral margins of pronotum armed with distinct tubercles in front of humeri; first antennal segment armed with distinct acute tubercles, larger near base.
    c. Pronotum with expanded, elevated lobes at each lateral angle, armed with four or five acute processes of similar size; head with prominent, multispinose tubercle behind each eye. (California)..... *balli* n. sp.
    cc. Pronotal angles not expanded, armed with one large tooth preceded by several smaller ones; head with tubercles behind eye smooth or slightly muricate. (United States, east of the Rocky Mountains)..... *antennator* Fabr.
  bb. Lateral margins of pronotum unarmed in front of humeral spine; first antennal segment armed with acute tubercles at base only (or none); subtropical or tropical species.
    c. Body castaneous, margins and angles of pronotum darker; dilation of third antennal segment not notched; venter refescent; dorsum of abdomen rosaceous; spines of pronotum remarkably long and slender. (Texas to Panama). *cuspidatus* Dist.
    cc. Body testaceous, pronotal margins concolorous with or paler than disc; dilation of third antennal segment notched; venter with black spots.
      d. Dorsum of abdomen black. (Mexico)..... *moestus* Burm.
      dd. Dorsum of abdomen subsanguineous, base and apex black. (South America)..... *armatus* Thunbg.

Chariesterus balli new species. (See Figure).

Head quadrate, armed on the disc with two longitudinal rows of two or three vertical spines each; prominent multispinose tubercles caudodorsad of each eye; antenniferous tubercles spinose at both obtuse lateral and acute mesal angles. Antennæ with first segment

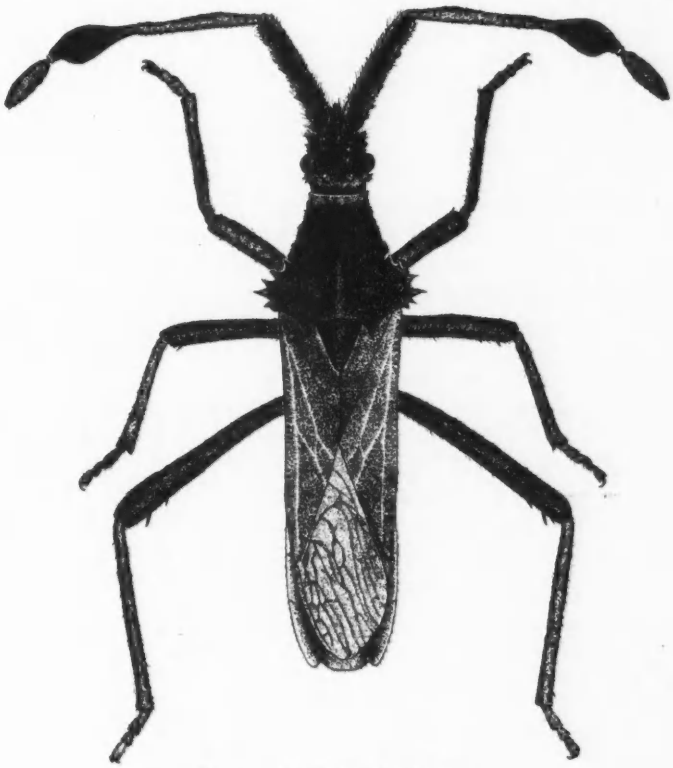


Fig. 1. *Chariesterus balli* n. sp.

strongly triquetrous, lateral carinæ with basal two-thirds armed with numerous acute tubercles, mesal carinæ unarmed except at base; second segment much more slender, shorter, compressed and slightly expanded near the middle; third segment longer than fourth, strongly expanded throughout three-fourths of the length, four-tenths as wide as long. Rostrum scarcely attaining posterior coxæ.

Pronotum more elongate than in *C. antennator*, with each lateral angle elevated, expanded, irregularly armed with three to five large subequal teeth, anterior and posterior lateral margins with several smaller teeth; posterior angles each with flat triangular tooth. Scutellum unarmed. Mesosternum and metasternum, in part, deeply sulcate. Posterior tibiæ shorter than femora. All femora armed with short spines near the apex.

Color black, marked with dark ferrugineous. Head black above, ferrugineous beneath, with a rufescent vitta below each eye, rugose; antenniferous tubercles wide, adjacent, black. Antennæ black, immaculate, except that second segment is ferrugineous; rostrum scarcely attaining posterior coxæ.

Pronotum and scutellum black, pubescent, and very rugose, former with narrow, scarcely perceptible median line paler and slightly sulcate. Corium ferrugineous. Membrane sooty black. Venter and legs dusky ferrugineous.

Cotypes: Two males, captured at Cabazon, California, by Dr. E. D. Ball, and now in his collection.

In the presence of spinose callosities behind the eyes, this species approaches *Plapigus*, while the parallel sided basal antennal segments and the shape of the pronotum indicate *Chariesterus* as the proper genus.

C. antennator is the only species which is likely to be confused with *balli* as all the others possess a single long spine at the humeral angles. The species here described is more slender than *antennator*, a deeper black in color, and with the lateral angles of the pronotum expanded and elevated and armed with four or five large teeth. The tubercle behind the eye is more prominently spinose than in any other species of the genus.

EIGHT NEW "JASSIDS" FROM THE EASTERN UNITED STATES.

Family Cicadellidae (Hemiptera-Homoptera)

J. G. SANDERS and D. M. DELONG, Harrisburg, Pa.

The mountain regions of Pennsylvania and certain less elevated sections of New Jersey, and those portions of Maryland and Virginia between the Chesapeake Bay and the ocean, have received but scant attention from collectors of Homoptera if existing records are dependable. Although relatively little collecting has been done to date, we are able to describe seven new species of distinct interest, while withholding other apparently new forms for more material and better data.

These new species are described from Pennsylvania, one from New Jersey and three from the Maryland-Virginia peninsula; with one exception, all collected by the senior author during the past two years.

Especially interesting and beautiful is the new Phlepsius collected near South Orange, N. J., by Mr. Harry B. Weiss, from "Hercules Club" (*Aralia spinosa*); and also the very distinct and beautifully marked Deltocephalus from grasses on the mountain top near Port Matilda in central Pennsylvania, taken by the senior author.

Platymetopius rubellus n. sp.

Plate XIII, Figs. 1, 2, 3, 4.

Form of *cuprescens* with long pointed vertex, but smaller and with reddish color above and on face. Female, 4.75; male, 4.25.

Vertex longitudinally concave, a little more than twice as long as width between the eyes, margins slightly concave, either side to a very acute apex. Pronotum short and broad. Not quite two-thirds as long as vertex, and more than twice as broad as long. Elytra rather short and broad, broadly rounded at apex. From side view, the front is concave and very acutely angled with vertex. Face long, frons extremely narrow, clypeus constricted just above middle, expanded to rounding apex.

Color: Generally reddish brown, shading toward infuscated apices of elytra. Vertex with median apical line and a line either side extending along margin half way to eyes, and then inward on disc, with faint traces toward median basal portion, pale. Median line deep and black on

basal half. Faint traces of vittæ on pronotum and scutellum; the latter with apex and point at middle of either side, white. Median impressed transverse line, black. Elytra reddish brown with veins darker, supernumerary costal veinlets and vermiculate markings brownish, heavier at apex. Apex with a white band. Areoles few and distinct; two along suture on posterior half of clavus, a row along anterior portion of apical cells and posterior portion of anteapical cells, and one at anterior end of first and second anteapical cells. Front and face uniform reddish brown, often flecked with reddish, and infuscated at apex of vertex, angular line long and very distinct, irregular, dark margin above and below. Eyes red.

Genitalia: Last ventral segment of female with wide sloping to rather prominent angles, then slightly concavely rounded to produced median truncated lobe. Whole segment dark bordered. Male valve broad and roundingly produced to a distinctly angled apex twice as long as preceding segment, which is concavely angled on posterior margin. Plates broad at base, wider than valve, gradually narrowed to sharp tips.

Described from two females and one male from Battle Point, Va., June 22, 1918, and a female from Parksley, Va., June 21, 1918. Collected by the senior author.

Platymetopius collaris n. sp.

Plate XIII, Figs. 5, 6, 7.

A blunt-headed pale species with pronotum and scutellum largely black. Length, Female, 5 mm.; Male, 4.5 mm.

Vertex nearly twice as long as width between the eyes. Posterior angle of head flaring. Pronotum strongly arcuate anteriorly, truncate posteriorly, obliquely cut to outer flaring angles. Elytra broadly rounded at tip. Approximately ten supernumerary veinlets along costal margin.

Color: Vertex dull pale orange, elongated median spot at apex, irregular spot at either side ivory white, between these and extending posteriorly, irregular lines and washing of brown merging and fading posteriorly. Median posterior spot white. Line behind eyes black. Pronotum dull yellow, median two thirds black or dark brown, with pale median line. Scutellum before transverse suture black or dull brown, apex bright yellow. Elytra pale to buff, apical cells clouded and with variable tiny vermiculate markings. Areoles few, white, two in clavus, one at base of each apical cell, and at apex of each anteapical cell. Supernumerary costal and apical veinlets, black or brown. Frons pale shading to dull orange on the cheeks. Pale line extending from tip of apex across eyes in well marked specimens. White "v" below apex indistinct. Venter mottled with gray and brown; pale orange on plates.

Genitalia: Female last ventral segment strongly and evenly produced to a blunt angle. Male valve large, half as large as plates, strongly produced to a blunt angle. Plates evenly narrowed to blunt tips.

Described from four females and one male swept from *Vaccinium* sp. on the mountain at Penfield, Clearfield Co., Pa., August 24, 1918, by the senior author. Type and paratype in authors' collections.

Deltocephalus delector n. sp.

Plate XIII, Figs. 8, 9, 10.

Similar in form and general appearance to *bilineatus* and *marginatus*, but much smaller, really a minute species with distinct markings. Length, male, 3 mm.

Head well produced, with apex distinctly pointed, as long as pronotum, about one-fourth longer on middle than width between the eyes. Pronotum about twice as wide as long, strongly arcuate in front, lateral margins very short, rounded. Elytra with clavus not reticulate and with middle anteapical cell strongly constricted at middle.

Color: Vertex creamy white, with two broad tawny bands extending from base to apex, where they converge and form two black triangular spots either side of white tip, and extend over margin. Behind these in each band a "v" shaped black spot inclined inwardly. A narrow black curved line extends from eye around ocellus on margin toward apex. Median white band distinctly narrowed to apex. Pronotum white, with four longitudinal tawny bands, one behind either eye, and the central two are extensions of the bands on vertex, continuing across scutellum. Elytra tawny with costal, sutural and apical margins and veins, white. A spot in distal portion of inner apical cell, the costal veinlets of the apical and anteapical cells, and a curved band on inner border of the apical white margin, black. Face pale, a spot on the outer margin of loræ, one above antenna, and inner line of antennal pit, brown. Beneath pale yellow, male plates with inner apical third black, but white margined.

Genitalia: Male valve short and broad, with nearly truncate apex. Plates three times length of valve, gradually sloping to broad truncated apices, the outer margins set with coarse spines.

Described from one male specimen swept from grasses by the senior author on the top of mountain between Port Matilda and Phillipsburg, Pa., August 23, 1918. A second specimen was taken, but escaped.

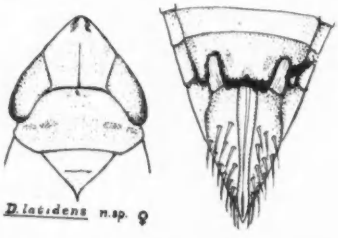
This species is very distinct from others of the *bilineatus* group, on account of its minute size and markings.

Deltocephalus latidens n. sp.

Closely resembling *misellus*, but slightly larger and more robust, with color pattern more vague and with distinct genitalia. Length 3 mm.

Vertex: Flat, slightly longer than width between the eyes, width across eyes almost equaling combined length of vertex and pronotum. Pronotum short, more than twice as broad as long, anterior margin well produced between the eyes. Elytra a little more than twice as long as broad, barely exceeded by abdomen. Face strongly inflated.

Color: Buff irregularly marked with pale orange. Vertex with traces of the four quadrants found in *misellus* usually appearing as a broken, broad transverse band between anterior margins of the eyes, and two indistinct triangular spots approaching apex, pale orange. Pronotum with traces of six longitudinal pale orange bands. Scutellum pale. Elytra generally darker with pale veins and cells pale orange with few dark markings. Two small spots along suture, one on middle of clavus, one just behind anterior cross vein, posterior margin of inner



anteapical and posterior margin of apical cells, brown. Face brown with traces of about eight arcs. Beneath yellow, heavily marked with brown. Ovipositor and broad tooth of last ventral segment in female brown. Male plates brown.

Genitalia: Female last ventral segment more than twice as long as preceding, posterior margin deeply, roundingly incised near lateral margins two-thirds to base leaving a broad central truncated tooth one-half width of entire segment produced beyond the lateral angles, which appear as long, narrow spatulate processes. Male valve broadly triangular, convex, twice as broad as long. Plates short and broad, sloping almost uniformly to broadly rounded apices. Outer margins set with fine white hairs.

Described from eleven females and eight males collected in 1916, at Amery, Wis., August 10; Cameron, Wis., August 7; Merrillam, Wis., August 5; Taylors Falls, Minn., August 16; Trout Lake, Wis., September 9; and Sturgeon Bay, Wis., July 19, 1914, by the authors.

This little species resembles *misellus* so closely in general appearance that the two have been confused. The female genital characters, however, are very distinct.

Phlepsius tenuifrons n. sp.

Plate XIII, Figs. 11, 12, 13, 14.

Form of *ramosus*, but shorter, more robust, head more foliaceous and with distinct genitalia. Length 7 mm.

Vertex well produced, almost entirely concave to sharp, foliaceous apex. More than twice as long as broad, almost twice as long at middle as next the eye. From side view almost entire vertex thin, foliaceous, and upturned. Pronotum short and broad, almost two and one-half times as wide as long. Elytra short and broad, flaring. Face very broad, and rapidly narrowed to base of clypeus. Upper portion very concave or almost angled to thin vertex.

Color: Vertex and pronotum pale with numerous brown irrorations. Median portion of vertex with an irregular brown longitudinal line. Face uniformly irrorate, with pale spot at upper angles of loræ. Elytra milky white; but very heavily marked with broken ramose lines; veins brown. Central portion more closely inscribed with brown, and forming a somewhat obscure saddle across the middle, having a suggestion of paler area toward base of elytra. Beneath uniform brown.

Genitalia: Last ventral segment of female about three and one-half times the length of preceding segment. Gradually rounded either side from half its length to posterior margin, forming rounding lobes instead of prominent angles. Then concavely arcuate to a broad produced median lobe, which is keeled, and narrowly notched at middle. Male valve more than three times as broad as long, roundingly angled at apex. Plates broad at base, then rather suddenly narrowed at about half their length and produced to blunt apices, a little longer than combined width at base. Pygofers very broad at base, convexly produced and sharply incurved toward tips.

Described from a pair collected at Greensburg, Pa. September 3, 1901, and September 2, 1902. Collected by Mr. M. Wirtner.

The short, broad body with sharp foliaceous head well distinguishes this species from its allies.

Phlepsius tinctorius n. sp.

Plate XIII, Figs. 15, 16, 17, 18.

A moderately robust, round-headed species with bright orange markings on vertex and scutellum. Female, 6 mm. and male 5 mm. long.

Vertex about three-fourths of width between eyes, very obtusely angled, almost evenly rounded and parallel margined, with apex narrowly but decidedly inflated before a distinct depression. Pronotum short and broad, truncate posteriorly with distinct flaring lateral angles broader than head. Scutellum transversely concave. Elytra broad with rounded tips. Face broad and flat with clypeus constricted at base and broadly truncate at apex.

Color: Vertex ivory white with small irregular black spot either side of apex; an irregular semicircular black spot above each ocellus vaguely connected by transverse wavy line following depression. Median suture black; on either side a large quadrangular orange spot posteriorly margined with irregular black lines. Pronotum tawny anteriorly, shading to darker, generally marked with vermicular brown lines. Scutellum bright orange with apex and triangular spot midway of lateral margins ivory white. Transverse suture with central spot and median line, and irregular lines extending anteriorly from lateral white spots, black. Elytra milky to smoky with pale tawny areas, uniformly marked with broken irregular lines; tip of clavus, margin of apex, spots of outer apical cell and costal cross-vein, black. Face black with close irregular white or tawny irrorations. Antennæ black, with pits and apices of basal segments white. Venter generally black or dark brown.

Genitalia: Female segment longer than preceding and smoothly truncate. Male valve half as long as preceding segment, broadly and bluntly angled; plates long triangular, evenly tapering to posterior third with long curved terete tips.

Described from eight females and one male collected by H. B. Weiss from "*Aralia spinosa*" at Irvington and South Orange, Essex Co., New Jersey, July 23 and August 1. Type and paratypes in authors' collections, and in New Jersey State Museum Collection.

Chlorotettix productus n. sp.

Plate XIII, Figs. 19, 20.

Small wedge-shaped species with well rounded vertex, a little more produced than in *viridius*. Female, length 5 mm.

Vertex roundingly produced, not angled, almost parallel margined; slightly longer on middle than next the eye, about twice as wide as long. Pronotum strongly and convexly produced, truncated posteriorly, lateral margins well rounded. Front broad, inflated.

Color: Dull yellowish green without definite markings. Vertex and frons shading to buff. Elytra greenish, subhyaline, distinctly shiny. Paler below, tip of ovipositor and bristles, yellowish.

Genitalia: Female last ventral segment one-third longer than preceding and longitudinally striated. Lateral angles roundingly produced. Posterior margin concavely sinuate to produced median third, slightly notched at middle. Pygofers with heavy bristles on posterior half.

The produced last ventral female segment distinguishes this species from others of the genus.

Described from three female specimens swept from a low shrub at Battle Point, Virginia, June 23, 1918, by the senior author. Type and paratypes in authors' collections.

Chlorotettix fumidus n. sp.

Plate XIII, Figs. 21, 22, 23.

Resembling *tergatus* in size and color, but narrower, with head well produced and angled. Length, female, 8 mm.; male, 7.5 mm.

Vertex produced, distinctly angled; one-half longer on middle than next the eye, and about twice as wide as long. Pronotum very convex anteriorly and almost truncate posteriorly, length one-half the width. Second apical cell much narrower than in *tergatus*.

Color of vertex dull pale orange; face pale straw-yellow. Pronotum and scutellum smoky green, elytra dark smoky. Body above black; beneath pale yellow.

Genitalia: Last ventral segment of female about one-half longer than preceding; obliquely produced to outer angle, with posterior margin truncate or slightly concave to broad deep median notch two-thirds distance to base. Male valve triangular, as wide as preceding segment, apex rounded and posterior margins slightly sinuate. Plate short and broad, convexly rounded to acute appressed tips.

Described from three female and two male specimens. Type specimen, female, collected at Mt. Alto, Pa., August 24, 1918, by T. L. Guyton. Two females from Moscow, Tenn., collected by the junior author, June 23, 1915; one male from Paris, Tenn., June 26, 1915, and one male from Speeceville, Pa., July 22, 1917, by the senior author. Type and paratypes in authors' collections.

EXPLANATION OF PLATE XIII.

1.—*Platymetopius rubellus* n. sp., head (dorsal view).
2.—head (side view). 3.—♂ genitalia. 4.—♀ genitalia.

5.—*Platymetopius collaris* n. sp., head.
6.—♂ genitalia. 7.—♀ genitalia.

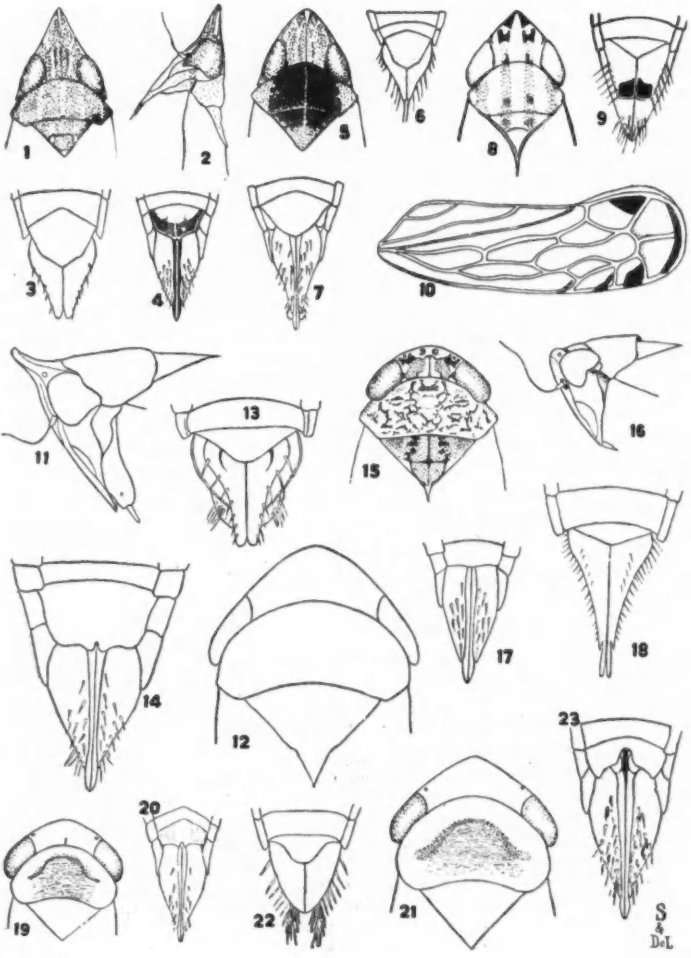
8.—*Deltocephalus delector* n. sp., head.
9.—♂ genitalia. 10—elytron

11.—*Phlepsius tenuifrons* n. sp., head (side view).
12.—head (dorsal view.. 13.—♂ genitalia. 14.—♀ genitalia.

15.—*Phlepsius tinctorius* n. sp., head (dorsal view).
16.—head (side view). 17.—♀ genitalia. 18.—♂ genitalia.

19.—*Chlorotettix productus* n. sp., head. 20.—♀ genitalia.

21.—*Chlorotettix fumidus* n. sp., head.
22.—♂ genitalia. 23.—♀ genitalia.



Sanders and DeLong.

NEW WESTERN SPIDERS

By RALPH V. CHAMBERLIN.

Most of the new forms of spiders described below were found in collections made by the writer in Utah in the latter part of August and the early part of September, 1917. The collections were made on Chalk Creek in the Uintah Mts., at elevations of from 7,300 to 10,000 ft. and at and near Fillmore, Millard Co. In addition to the spiders from Utah, a number of new forms from other localities noted while identifying the collections mentioned are here described.

DICTYNIDÆ.

Amaurobius utahensis sp. nov.

Male—Carapace, sternum, labium, endites and legs yellow, without any reddish tinge, the legs unmarked. Abdomen blackish, the anterior middle region of dorsum obscure yellow, the posterior half with dark marks which are, excepting the first ones, only vaguely separated from each other. Anterior row of eyes procurved; medians close together, but more than their diameter from the laterals. Posterior eyes much smaller than the anterior ones, the medians slightly smaller than the laterals, about twice their diameter apart and about twice as far from the laterals. Area of median eyes rectangular, being as wide behind as in front, longer than wide. Distal joints of palpus heavier than in *nevadensis*. Tibial apophyses very similar to those of the species mentioned; but the exterior one distally less uncate, the median one basally broader and more narrowed distad, and the mesal one obviously broader and shorter and differing particularly in being united with or carried forward on a common base with the median one much farther, the ridge uniting the two in *nevadensis* being slight or obsolete.

Length, 11.5 mm. Length of cephalothorax, 6.1 mm. Length of tib. + pat. I, 6.4 mm.; of tib. + pat. IV, 6.7 mm.

Type—M. C. Z. 414, Utah: Fillmore.

This species is nearest *A. nevadensis* Simon. It is a more robust species, wholly lacking the reddish cast characteristic of *nevadensis*. It differs chiefly otherwise in the details of the male palpus as indicated above and also presents minor differences in the eyes.

Amaurobius nomeus sp. nov.

Female—Carapace and sternum light yellowish brown, becoming blackish in anterior portion of pars cephalica. Legs paler. Labium and endites chestnut, pale across tips. Cheliceræ black. Abdomen above greyish yellow, with a narrow, median longitudinal dark mark extending well caudad of the middle, where its point ends at the angle of a transverse chevron line, which is followed by several others; in front of the first chevron there are two or more lines running obliquely caudoectad from the edge of the median mark. Sides of abdomen darkened by numerous spots and streaks as is also the venter on which they tend to form two longitudinal stripes and a narrower median line separated by clear spaces. Anterior row of eyes procurved; median eyes smaller than the laterals, their radius or a little more apart, and a little more than their diameter from the laterals. Posterior row of eyes longer than the anterior; eyes smaller than the anteriors; the medians smaller than the laterals. Median eyes forming a trapezium wider behind than in front in ratio of about 25:20 and wider behind than long, the length scarcely exceeding the anterior width. Tibia I armed beneath with two pairs of spines, none being present at distal end; tibia with a single spine at distal end in addition to the two pairs. Epigynum smooth, median interval narrow, the process ventrally rounded. See Plate XIV, Fig. 1.

Male palpus is shown in Plate XIV, Fig. 2.

Length 11.2 mm. Length of cephalothorax, 5 mm. Length of tib. + pat. I, 4.1 mm.; of tib. + pat. IV, 4.3 mm.

Type—M. C. Z. 416.

Utah: Uintah Mts., 10,000 ft.

This species has resemblance to *A. benneti B* and *A. pictus S.* When placed alongside of these species the cephalothorax is seen to be obviously more narrowed at the anterior end. It is distinct in the details of epigynum and eye arrangement.

Dictyna uintana sp. nov.

Female—Carapace fuscous or nearly black, clothed with white hairs. Sternum blackish. Legs yellow, distinctly annulate with black, the annuli of tibia and metatarsus deepest, the femora with a submedian and a distal annulus, patella with annulus at distal end, tibia with an annulus at each end and metatarsus with an annulus at distal end and a broader, but less distinct proximal one. Abdomen testaceous; at base above with a long triangular to hour-glass shaped dark brown mark followed by a number of chevron marks, of which the first is connected by its apex with the basal mark; caudal end of dorsum typically covered by a solid black area; sides of abdomen darkened above by streaks and spots of brown; venter commonly showing an often vague longitudinal median dark band. Anterior row of eyes

straight; median eyes decidedly smaller than laterals, scarcely their diameter from the laterals, one half their diameter from each other and about the same distance, or slightly farther, from the lower edge of clypeus. Posterior row of eyes straight; median eyes obviously larger than the anterior medians, once and a quarter or scarcely more their diameter apart and near the same distance from the laterals; posterior laterals equal to the anterior laterals. Area of median eyes a little wider behind than in front. In front view the inner edges of the chelicerae are obviously curved ectad over most of their length, as shown in Plate XIV, Fig. 3; Epigynum as shown in Plate XIV, Fig. 4.

Male—Chelicerae with a low rounded tubercle or tooth at exterior angle of base. Palpus with tibial apophysis short, but rather stout. Cf. Plate XIV, Fig. 5.

Type—M. C. Z. 405. XIV, Utah: Uintah Mts.; Chalk Creek, elevation, 7,500 ft. Webs on boughs of pine trees.

Resembles *sublata*. The latter, among other differences, has the eyes of the anterior row obviously more nearly equidistant and the form of the epigynum different.

Dictyna coloradensis sp. nov.

Female—This species has to some extent been identified with *D. arundinaceoides* Keys, but is not that species, which seems to be really the *D. sublata* of Hentz. Carapace and sternum fuscous. Legs yellowish or pale brown, without distinct markings or often with femora darkened and tibiæ and metatarsi annulate at distal end and with less distinct annuli toward proximal end. Abdomen above with the usual triangular mark at base; behind this two rows of annular markings more or less connected by dark lines or chevrons between them. Anterior row of eyes straight; median eyes a little smaller, separated by about their diameter, very slightly closer to laterals. Clypeus rather low, the height being between once and a half and twice the diameter of an anterior median eye.

Posterior row of eyes straight; eyes equidistant. Area of median eyes wider behind than in front. Epigynum shown in Plate XIV, Fig. 7.

Male—Darker than the female. Femora darkened and a distinct dark annulus at distal end of tibiæ and metatarsi and a less distinct one proximally, or legs sometimes lacking these dark markings. Clypeus much higher than in the female and median eyes smaller. Chelicerae dentate at base toward ectal side as shown in Plate XIV, Fig. 6. Process of tibia of palpus stout, of moderate length, distally bi-dentate. Cf. Plate XIV, Fig. 8.

Length of female up to 3.5 mm.

Type—M. C. Z. 395. Colorado: Colorado Springs (R. V. Chamberlin, coll.); Eldora; Pagosa Springs; Fort Collins, etc. New Mexico: Beulah; Mesilla.

Dictyna bellans sp. nov.

Female—Carapace and sternum pale brown to yellow, sometimes of slight reddish cast. Legs yellow. Abdomen grey, under the lens showing the usual network of fine dark lines; a triangular dark spot on base above followed by two or three pairs of large dark dots which may be connected on each side. Venter immaculate grey. Anterior median eyes a little smaller than the laterals. Posterior row of eyes recurved. Area of median eyes as wide in front as behind. Epigynum as shown in Plate XV, Fig. 4.

Male—The abdomen in the types is either wholly immaculate or shows the dorsal markings only vaguely. The basal tibial process of the male palpus is erect, moderately long, and shows but a single distinct tooth or point at distal end. Toward anterior end of tibia above is a second much shorter process or tooth as shown in Plate XV, Fig. 5. Process at base of chelicera long and curved. See Plate XV, Fig. 3.

Length of female up to 2.8 mm.

Type—M. C. Z. 403. Mississippi (R. V. Chamberlin.)

Dictyna sociella sp. nov.

Female—Carapace fuscous, the pars cephalica a little paler. Sternum dusky brown or fuscous. Legs yellow, some darker annuli faintly traceable. Abdomen on basal half of dorsum with two connected triangular dark marks and the usual line of more or less connected dark spots on each side behind, elsewhere the usual fine network of dark lines over a light ground. Anterior eyes nearly equidistant, the median eyes only slightly smaller than the laterals. Posterior eyes also nearly equidistant. Area of median eyes a little wider behind than in front. Epigynum, Plate XV, Fig. 8.

Length, 3.2 mm.

Type—M. C. Z. 412. Washington: Wawawai.

Distinguished particularly by the form of the epigynum and by the eye relations.

Dictyna insolens sp. nov.

Male—Carapace and sternum fuscous. Legs yellow, somewhat dusky, the tibiæ and more especially the metatarsi obscurely annulate. The narrow annulus at distal end of metatarsi most distinct. Abdomen dorsally with a black triangular mark at base followed by a pair of dark spots and then two heavy chevrons behind which is a clear area; sides darkened; venter light. Anterior median eyes smaller than the laterals. Posterior eyes equidistant. Area of median eyes a little wider behind than in front. Process of tibia of male palpus very short and proportionately wide with the anterior tooth much the larger. See further Plate XV, Fig. 6. Chelicera with basal tooth slight, rounded.

Length, 2 mm.

Type—M. C. Z. 409. Washington: Olympia.

Dictyna vincens sp. nov.

Female—Carapace and sternum fuscous. Legs yellow to pale brown. Abdomen above at base with a black mark having caudal end excised in an obtuse re-entrant angle and on each side the usual dark lines radiating from its angles and edges; behind the middle first a pair of widely separated dark spots and then typically two exceptionally thick chevrons, which sometimes give the caudal end the appearance of being almost solid black; sides often darkened; venter either uniform or with a dusky or blackish band over its length, or with a black area only in front of spinnerets. Anterior median eyes essentially equaling the laterals, their diameter apart, closer to the laterals. Posterior eyes equidistant. Area of median eyes as wide in front as behind. Epigynum, Plate XV, Fig. 1.

Male—In what is regarded as the male of this species the coloration is similar to that of the female though the general appearance of the abdomen is darker and more uniform with the markings less distinct and sometimes almost obliterated. The palpus is shown in Plate XV, Fig. 2.

Length of female, 3.25 mm.; of male, 2.5 mm.

Type—M. C. Z. 410. Washington: Olympia.

Dictyna olympiana sp. nov.

Male—This small form has the usual general coloration; the carapace and sternum dusky brown; legs yellow; abdomen at base above with a median dark line expanding into a triangular spot in front of middle, this followed behind by the usual pairs of longitudinally connected spots, the sides also dark. Anterior median eyes smaller than the laterals and than the posterior medians. Area of median eyes clearly wider behind than in front. The species is readily characterized by the large size of the tarsus of the palpus and the form of the particularly large palpal organ. The process of tibia is small, erect, and bidentate, the teeth being equal. See further Plate XV, Fig. 7. Chelicera rather small, slightly bulging at base in front, but without a true process or tooth.

Length, 1.7 mm.

Type—M. C. Z. 408. Washington: Olympia.

Dictynoides gen. nov.

Pars cephalica broad, low, not gibbous. Anterior row of eyes straight, the eyes equal or the medians smaller. Lateral eyes on each side subcontiguous. Posterior row of eyes straight, eyes equidistant or the median farther apart than from the laterals. Area of median eyes quadrate or trapeziform, wider than long. Clypeus with height much exceeding the diameter of the anterior eyes. Cheliceræ long, with lower margin armed with two or three teeth. Labium broad, moderately narrowed distad, extending a little beyond middle of endites. Endites oblique, inclined. Cribellum entire. Legs without spines.

Genotype—*D. arizonensis* sp. nov.

Includes also *Lathys trivittata* Bks., known from New Mexico. The genus differs from Lathys in its inclined endites and much higher clypeus, and from Dictyna in its shorter labium and lower, less convex, pars cephalica.

Dictynoides arizonensis sp. nov.

Female—Carapace rufous brown along each side, the median and a marginal stripe on each side paler; along the pars cephalica and converging caudad are three bands of white hair as in trivittata. Sternum dusky yellow to nearly black. Legs yellow, not annulate. Abdomen pale with some darker spots above; clothed with white hair. Anterior row of eyes straight; eyes equidistant or the medians a little farther from each other than from the laterals; the medians smaller than the laterals. Height of clypeus more than twice the diameter of the anterior median eyes, slanting conspicuously forward from above below. Posterior row of eyes straight or nearly so, eyes equal in size and obviously larger than the anterior median, nearly equidistant, the medians slightly farther apart than from the laterals. Area of median eyes wider behind than long (cir. 12:10) and obviously wider behind than in front, the anterior width being equal to the length. Epigynum as shown in Plate XVI, Fig. 1.

Length, 5 mm. Length of tib. + pat. I, 2.8 mm.; tib. + pat. IV, 1.8 mm.

Type—M. C. Z. 393. Arizona: Huachuca Mts.; Miller Canyon, elevation 5,600 ft. (W. M. Wheeler, 17th Nov., 1910).

ULOBORIDÆ.

Uloborus utahensis sp. nov.

The types of this species, which are not quite fully mature females, seem readily distinguishable by pronounced differences in coloration in connection with structural features. Carapace and sternum black or nearly so, with the usual clothing of white hair. Leg I with femur and patella entirely black, the tibia black, excepting a narrow ring at proximal end, and the metatarsus with a narrow black annulus at each end and two broader ones in the intervening region, the tarsus dark except at ends. Leg II has the femur black throughout, with no narrow pale median annulus; metatarsus with two broad dark annuli or these indistinctly separated, each close to its end of the joint. Femur III black, with one pale annulus distad of middle and one less distinct at proximal end; tibia with a pale annulus at proximal end and a submedian one; metatarsus pale at proximal end and at middle. Leg IV with femus having two pale annuli of which the more proximal is commonly incomplete below; the other joints as in leg III. The abdomen somewhat elongated, without any distinct humps above; dark, being covered with a dense network of black lines, a brown median longi-

tudinal black stripe above at base; venter blackish with a pale longitudinal line on each side. Posterior row of eyes rather strongly recurved, the median eyes much farther from each other than from the laterals. Area of median eyes longer than wide, a little narrower in front than behind.

Length, 3 mm. Length of cephalothorax, 1 mm. Length of tib. + pat. I, 1.54 mm.; of tib. + pat. IV, 1.13 mm.

Type—M. C. Z. 476. Utah: Fillmore.

DRASSIDÆ.

Drassodes robinsoni sp. nov.

Female—Carapace and sternum yellow of slightly reddish-brown cast. Legs yellow. Labium and endites brown, pale at tips. Abdomen yellowish grey, dusky on sides, especially posteriorly; a weakly indicated hestate outline from base to middle, with very faintly indicated chevron lines traceable behind it. Cheliceræ deep brown. Lower margin of furrow of chelicera armed with two rather small teeth. Anterior row of eyes procurved; the eyes subequal or the medians a little the smaller; median eyes nearly their diameter apart, half as far from the laterals. Posterior row of eyes procurved; median eyes their larger radius apart, between once and a half their diameter apart from the laterals. Tibiæ I and II armed beneath with a single spine between middle and distal end. Posterior tibiæ armed with a spine above at base and with one distad of middle. Epigynum as shown in Plate XVI, Fig. 2.

Length, 9.6 mm. Length of cephalothorax, 3.9 mm. Length of tib + pat. I, 3.9 mm.; of tib. + pat. IV, 3.3 mm.

Type—M. C. Z. 418. Utah: Fillmore.

Dedicated to Mr. Joseph Robinson, of Fillmore, who gave enthusiastic assistance in the collecting of spiders in that region.

Drassodes gosiutus sp. nov.

Male—This species belongs in the *lapidosus* group. It is characterized among North American species in wholly lacking a tibial apophysis on the male palpus and in having the lower margin of the furrow of the chelicera bearing but a single, noduliform tooth. Carapace, sternum and legs yellow, the abdomen light grey or whitish. Anterior row of eyes procurved; median eyes larger than the laterals, about three-fourths, or somewhat more, their diameter apart and their radius from the laterals. Posterior row of eyes much longer than the anterior, obviously procurved; median eyes much larger than the laterals, subelliptic, somewhat angulate, only about their lesser radius apart, more than their long diameter from the laterals. Tibiæ I and II armed beneath distad of the middle with a single spine. Metatarsi I and II armed beneath its base with a single spine. The claw of the chelicera

long and somewhat sinuous. Upper margin of furrow of chelicera armed with three teeth of which the most proximal is nearer the median than is the most distal. Tarsus and bulb of male palpus proportionately small and slender; the tarsus bearing two long spines on its ventral face distad of the bulb. See Plate XVI, Fig. 3.

Length, 7.5 mm. Length of cephalothorax, 3.5 mm. Length of tib. + pat. I, 4 mm.; of tib. + pat. IV, 4 mm.

Type—M. C. Z. 389. Utah: Fillmore.

Drassodes melius sp. nov.

Female—Carapace and sternum pale testaceous, the legs more yellowish. Abdomen above dark brownish grey with a somewhat obscure, darker, median longitudinal stripe with vaguely indicated chevron marks behind, the venter somewhat lighter, much so in front of the epigastric furrow; the epigynum dark chestnut. Anterior row of eyes procurved; eyes subequal; median eyes nearly their diameter apart, a little less than their radius from the lateral. Posterior row of eyes straight; eyes smaller than the anterior ones and the medians slightly smaller than the laterals; median eyes a little less than once and a half their diameter apart and a little more than that distance from the laterals. Area of median eyes quadrate, as wide in front as behind. Lower margin of furrow of chelicera armed with two stout teeth. Tibiæ I and II each armed beneath with a single submedian spine. Posterior tibiæ not armed above at base. Epigynum as shown in Plate XVI, Fig. 5.

Male—Palpal organ as shown in Plate XVI, Fig. 4.

Length of female, 11 mm. Length of cephalothorax, 4.1 mm. Length of tib. pat. I, 4 mm.; of tib. pat. IV, 5 mm.

Length of male, 8.8 mm. Length of cephalothorax, 3.7 mm. Length of tib. + pat. I, 5 mm.; of tib. + pat. IV, also 5 mm.

Type—M. C. Z. 419. Utah: Uintah Mts., 10,000 ft.

Herpyllus oabus sp. nov.

Male—Carapace, legs and sternum yellow, without markings. Endites whitish across tips. Abdomen yellowish grey, darker above than beneath, without definite markings. Anterior row of eyes procurved; eyes about their diameter from edge of clypeus; median eyes larger than the laterals, scarcely their radius apart, closer to the laterals. Posterior row of eyes slightly procurved; eyes somewhat smaller than the anterior, the medians smaller than the laterals; median eyes nearly once and a half their diameter apart, closer to the laterals. Tibia I armed beneath with two pairs of spines, one pair basal and one submedian. Tibia II armed beneath with five spines, there being an unpaired spine at base, a pair at middle, and a pair of smaller ones at the distal end. Metatarsi I and II each armed beneath with two pairs of spines. Male palpus as shown in Plate XVI, Fig. 6.

Length, 4.6 mm. Length of cephalothorax, 2.4 mm. Length of tib. + pat. I, 2.4 mm.; of tib. + pat. IV, 2.8 mm.

Type—M. C. Z. 386. Utah: Fillmore.

Zelotes tuobus sp. nov.

Female—Carapace black, in part of a dull chestnut cast. Sternum dense black. Legs black, of slightly brownish cast, excepting the tarsi, which are paler. Endites blackish, paler across distal end. Abdomen black or nearly so, a little paler, greyish black, beneath. Anterior row of eyes strongly procurved, the median eyes lying above the line connecting the centers of the laterals; laterals fully twice the diameter of the medians; the medians about their diameter apart, but very close to the laterals. Posterior row of eyes straight; median eyes a little smaller than the laterals, about three-fourths their diameter apart, a little farther from the laterals. Quadrangle of median eyes obviously longer than wide, slightly wider behind than in front. Tibiæ I and II unarmed beneath. Metatarsi I and II armed beneath at base with one pair of spines. Posterior tibiæ not armed above. Epigynum as shown in Plate XVI, Fig. 7.

Length, 9.5 mm. Length of cephalothorax, 3.9 mm. Length of tib. + pat. I, 3.6 mm.; of tib. + pat. IV, 4.2 mm.

Type—M. C. Z. 387. Utah: Fillmore.

This species is very close to *Z. ater* (Hentz). The epigynum is proportionately longer with the anterior pockets obviously closer together and the inner lateral elevated edges also less widely separated.

PHOLCIDÆ.

Psilochorus utahensis sp. nov.

Cephalothorax pale yellow. Legs darker yellow. Abdomen grey, with some darker mottling. Posterior row of eyes straight; median eyes nearly once and a half their diameter apart, contiguous with lateral eyes, about their radius from anterior laterals and three-fourths their diameter from anterior medians. Characterized by having femur I in the female shorter than femur IV, the reverse of the condition in the male. Process of chelicera in male large, arising at base and projecting prominently forward and downward, at tip acutely pointed and curving mesoventrad, (Plate XVII, Fig. 1). The species is characterized particularly by the details of structure of the male palpus. In this the femur is slender from base to a little beyond middle, with the distal end strongly enlarged; at base on ectal side an elongate tubercle or swelling and a small process or tubercle from ventral edge at distal end. The exterior process of the palpal organ straight, narrowest at middle, and differing from that of *pulullus* and *californiæ* in appearing bifid at distal end. (Plate XVII, Fig. 2).

Length of female, to 4.4 mm. Length of tib. + pat. I, 4.75 mm.; of tib. + pat. IV, 5 mm.

Type—M. C. Z. 451. Utah: Clear Lake; Fillmore; Fillmore Canyon; Pine Canyon; et cetera.

LINYPHIIDAE.

Linyphia latescens sp. nov.

Female—Dusky yellow, darker at margin, the eyes edged with black. Legs also yellow, the femora and patellæ dusky, the tibiæ with a broad annulus proximad of middle and a narrower, deeper one at distal end, the metatarsi also similarly annulate. Sternum blackish. Abdomen grey, with abdomen crossed, excepting at anterior end, by a series of heavy blackish chevron marks connected by a more obscure median longitudinal dark line; sides dusky. Posterior row of eyes straight, the median eyes a little less than their diameter from the laterals, nearer to each other. Anterior row of eyes a little procurved, the medians much smaller than the laterals, less than their diameter apart, obviously more than their diameter from the laterals. Area of median eyes as long as wide or very slightly longer.

Male—Coloration as in female. Palpus as shown in Plate XVII, Fig. 3. Embolus coiled in a circle at distal end.

Length of female, 2.2 mm. Length of cephalothorax, .9 mm. Length of tib. + pat. I, 1.36 mm.; of tib. + pat. IV, 1.25 mm.

Type—M. C. Z. 429. Utah: Uintah Mts.; Chalk Creek.

Linyphia orinoma sp. nov.

Female—Carapace, legs, cheliceræ and endites yellow, without markings. Sternum and labium dusky or blackish, the color of the former appearing denser toward edges. Abdomen greyish yellow, with a few scattered small silvery dots and sometimes a dusky area at base of spinnerets on each side and occasionally also a dusky area in front of this; with no trace of dorsal dark markings, such as occur in *insignis*. Posterior row of eyes straight, the median eyes slightly nearer to each other than to the laterals, separated by their diameter or a little more. Anterior row of eyes straight; median eyes smaller than the laterals, their radius or less apart, nearly their diameter from the laterals. The epigynum projects in a straight, finger-like process, which is a little clavately expanded distad and is rounded at the end, where it has openings closer together than those of *insignis;* the dorsal surface just proximad of the tip having a deep lunate impression with concavity caudad, the form and position of this impression differing strongly from that of *insignis*. (Plate XVII, Fig. 4).

Length, 3.25 mm. Length of tib. + pat. I, 2.2 mm.

Type—M. C. Z. 427. Utah: Millard County; Clear Lake. Also a not fully matured specimen in Uintah Mts. on Chalk Creek.

Evidently close to *insignis* from which distinguished by the uniform presence of silver-colored spots on the abdomen, with absence of dorsal markings and particularly by the detailed structure of the epigynum.

Bathyphantes fillmoranus sp. nov.

Female—Carapace and sternum dusky yellow, the sternum the darker. Legs yellow. Abdomen above white, broken into closely arranged spots, a median dorsal line from which oblique lines on each side extend in an anastomosis. Venter greyish, with a few scattered small white dots. Posterior row of eyes straight; median eyes less than their radius apart, and about three-fourths their diameter from the laterals. Anterior row of eyes straight; medians smaller than laterals, less than their radius apart, more than their radius but less than their diameter from the laterals. Clypeus much narrower than length of area of median eyes. Upper margin of furrow of chelicera with six teeth, the lower margin with five much smaller ones. For epigynum see Plate XVII, Fig. 5.

Length, 2.2 mm. Length of cephalothorax, 1 mm. Length of tib. + pat. I, 1.25 mm.; of tib. + pat. IV, 1.13 mm.

Type—M. C. Z. 425. Utah: Fillmore Canyon.

Grammonota orites sp. nov.

Male—Cerapace dusky yellow-grey, with the eyes edged with black. Sternum and labium dusky over yellowish to nearly solid black. Legs, endites and cheliceræ yellow. Abdomen dusky over a paler background to nearly solid black; dorsum without definite markings. Posterior row of eyes slightly procurved, eyes equidistant, separated by nearly their diameter. Anterior row of eyes straight; median eyes much smaller than the laterals, hardly their diameter from the latter, nearer to each other. Clypeus a little wider than the eye area. Pars cephalica rising behind eye area as usual; crossed by a single median longitudinal series of setæ, which are longest just caudad of the eyes. Upper margin of furrow of chelicera with four or five large teeth, the lower margin with several much smaller ones. Tibial apophysis of palpus large, plate-like, with mesal side produced forward as a one-pointed process which curves ectad at tip. See Plate XVII, Fig. 8.

Female—The epigynum is shown in Plate XVII, Fig. 7.

Length, 2.3 mm.

Type—M. C. Z. 440. Utah: Uintah Mts.; Chalk Creek, 7,500 ft.

Distinguished from other North American species by the form of the tibial process of the male palpus and the structure of the palpal organ.

Grammonota simplex sp. nov.

Male—A smaller and paler species than the preceding one from which it is at once distinguishable in lacking the conspicuous tibial apophysis of the palpus. Carapace dusky yellow with the darker shield-shaped area at posterior end of pars cephalica; the sternum darker. Legs yellow. Abdomen blackish to grey. Posterior row of eyes straight, the eyes equidistant. Anterior row of eyes straight, eyes close together, sometimes appearing nearly equidistant, but most commonly with the medians nearer to each other than to the laterals; the medians smaller than the laterals. Tibia of palpus wholly lacking an apophysis at distal end above. See Plate XVIII, Fig. 1.

Female—Epigynum as shown in Plate XVIII, Fig. 2.

Length of male, 2 mm. Length of cephalothorax, .9 mm. Length of tib. + pat. I, .8 mm.

Type—M. C. Z. 432. Utah: Uintah Mts.; Chalk Creek, 7,300 ft.

Grammonota obesior sp. nov.

Female—Carapace comparatively low, yellowish of slightly orange cast with a black marginal line on each side; eyes edged with black. Sternum dusky. Abdomen blackish, under the lens showing numerous minute light dots and some light lines at sides of dorsum. Eyes as in the preceding species. Abdomen proportionately broader and higher than in the preceding forms. Distinguishable by the characteristic form of the epigynum which is represented in Plate XVII, Fig. 6.

Length, .2 mm. Length of cephalothorax, .8 mm.; width, .66 mm. Length of tib. + pat. I, .8 mm.; of tib. + pat. IV, .9 mm.

Type—M. C. Z. 437. Utah: Uintah Mts.; Chalk Creek.

Grammonota fratrella sp. nov.

Female—A smaller species readily distinguishable by the form of the epigynum. The carapace is slightly dusky over a dilute yellowish background, the eyes and lateral borders narrowly edged with black. Sternum very dusky, nearly black. Legs pale yellow. Abdomen black or nearly so, without definite markings. Posterior row of eyes straight; median eyes their diameter apart, slightly nearer to the lateral. Anterior row of eyes a little recurved; median eyes much smaller than the laterals, scarcely their radius apart, their diameter from the laterals. Clypeus narrower than eye area. Epigynum as shown in Plate XVIII, Fig. 3.

Length, 1.64 mm. Length of cephalothorax, .76 mm. Length of tib. + pat. IV., .9 mm.

Type—M. C. Z. 443. Utah: Uintah Mts., 8,500 ft.

Cornicularia monticolens sp. nov.

Female—Carapace dusky yellow to dusky chestnut, the lateral margins solid black; eyes edged with black. Sternum more blackish than carapace. Labium and endites also dusky. Legs yellow, often dusky, with distal ends of coxæ beneath often narrowly lined with black. Abdomen blackish, without definite markings. Posterior row of eyes straight or slightly recurved, the median eyes farther from each other than from the laterals. Nearly twice their diameter apart. Anterior row of eyes straight; median eyes much smaller than laterals, nearer together, but well separated from the laterals. Area of median eyes slightly wider than long. Clypeus moderately oblique, impressed transversely below eyes, slightly higher than length of median eye area. Epigynum as shown in Plate V, Fig. 4.

Male—Anterior end of pars cephalica conspicuously elevated, rounded, highest just back of anterior median eyes, bulging forward a little over clypeus which is incurved above its lower edge. A long auditory hair at distal end of tibia IV. In the palpus the tibial aphysis is much more slender than in e. g. *Cornicularis spiralis*, the genotype, and is slenderly uncate at tip. The embolus is strongly coiled in a flat spiral, which is not in part covered as it is in *spiralis*, etc. See further, Plate XVIII, Fig. 5.

Length of female, 1.7 mm. Length of cephalothorax, .77 mm. Length of tib. + pat. I, .63 mm.; tib. + pat. IV, .7 mm.

Type—M. C. Z. 444. Utah: Uintah Mts.; Chalk Creek.

This species in a group with the eastern *C. spiralis* Em. and *C. vigilax B.*, of Europe. It is strongly different from those species in the form of the tibial apophysis of the male and in the details of the eye relations, etc.

Diplocephalus wamotsus sp. nov.

Female—Carapace dusky yellow to dusky brown with the frontal gibbosity paler, often whitish, the sternum somewhat darker than carapace. Legs yellow. Abdomen grey. Posterior row of eyes more procurved than typical, but the tangent to anterior edges of its median eyes intersecting the posterior portion of the laterals; median eyes nearly their radius apart, not quite twice as far from the laterals. Anterior row of eyes slightly procurved; the medians much smaller than the laterals, sub-contiguous with each other, but widely separated from the laterals. Clypeus about as wide as length of median ocular area. Area of median eyes much longer than wide. Upper margin of furrow of chelicera armed with three well separated, long teeth; the margin with a close-set series of several very small teeth. Epigynum as shown in Plate XVIII, Fig. 7.

Male—Post-ocular gibbosity broad, with each antero-lateral corner extended as a rounded protuberance, its median region and a narrower inter-ocular region in front of it rather densely pilose; posterior median eyes borne at base of its anterior face. Posterior row of eyes very strongly procurved; the medians separated by nearly their diameter,

three times as far from the laterals. The clypeus obviously more protuberant than in female, as usual. Tibia of palpus with anterior end extended into a thin, cup-like plate embracing the base of the tarsus like a calyx and bearing a slender chitinous process from below its distal end. See Plate XVIII, Fig. 6.

Length of male, 2.8 mm. Length of cephalothorax, 1.2 mm.; width, .9 mm. Length of tib. + pat. I, 1 mm.; of tib. + pat. IV, 1.36 mm.

Type—M. C. Z. 446. Utah: Chalk Creek.

Wubana gen. nov.

Posterior row of eyes a little procurved; the median eyes farther from each other than from the laterals. Anterior row of eyes slightly procurved; eyes close together, the medians from a decidedly smaller to nearly as large as the laterals; eyes equidistant or with the medians nearer to each other than to the laterals. Area of median eyes trapeziform, much wider behind than in front, from a little longer than wide to wider than long (some males). Clypeus as high as eye area. Thoracic stria obscure. Pars cephalica in male rising behind the eye area; piligerous in a median longitudinal stripe, with a brush of longer setæ just behind the eyes which may or may not be elevated on a distinct process, one hair of this brush typically stouter, more spiniform than the others. Sternum broad, extending between posterior coxæ. Male palpus with patella not enlarged; tibia prolonged in an elongate lobe of ordinary texture along basal part of ectal side of the tarsus. Legs long and slender, anterior tarsi shorter than metatarsi, and metatarsi shorter than tibiæ.

Genotype—*W. drassoides* (Emerton).

In addition to the genotype, originally described under *Bolyphantes* and also later referred to *Sphecozone*, the new form described below and apparently also *Bolyphantes pacificus* Banks, later referred to *Nematogmus*, belong in this genus. The genus differs from *Nematogmus* in having the posterior median eyes farther from each other than from the laterals with the row at most but gently procurved, in its longer legs, in lacking postocular impressions in the male, in the form of the tibia of the male palpus and in not having the tarsus of the latter deeply bifid at the apex. From *Sphecozone* the genus differs, e. g., in having the median eyes of the posterior row farther from each other than from the laterals, in not having them borne upon the frontal lobe sometimes present in the male, in lacking the notably long pedicle to the abdomen, and in the form of the male palpus. I have taken the genotype, *W. drassoides*, originally described from Mt. Carmel, in Connecticut and until now not since recorded from elsewhere, also in the Uintah Mts., of Utah, at an elevation of 7,500 ft.

Wubana retrahens sp. nov.

Male—Cephalothorax and legs dull fulvous. Eyes edged with black. Abdomen greyish; marked above as in *W. drassoides* with a median longitudinal black line at base followed behind by several transverse dark lines; sides and part of venter dusky. Eyes of anterior row equidistant, the medians a little smaller than the laterals. Posterior row of eyes gently procurved; medians scarcely their diameter apart, nearer to the laterals. Area of median eyes longer than wide. Piligerous stripe extending from caudal end of pars cephalica forward between eyes, with no special process of elevation behind eyes beneath the brush of longer hairs. Palpus as shown in Plate XVIII, Fig. 10.

Length near 2 mm.

Type—M. C. Z. 447. Utah: Fillmore.

The male is at once distinguishable from those of *W. drassoides* and *W. pacifica* in lacking the postocular piligerous eminence. It is notably different from *W. drassoides* in having the posterior median eyes much closer together, with the area of median eyes longer than wide instead of wider than long. The structure of the male palpal organ is also a feature readily distinguishing the species.

Hilaira uta sp. nov.

Female—Carapace, sternum and endites dusky over a light brown ground, less often yellowish, the labium and cheliceræ darker. Legs dusky light brown to yellow. Abdomen grey, more or less dusky, with no markings. Posterior row of eyes straight; median eyes their diameter apart, once and a half as far from the laterals. Anterior row of eyes substraight, being very slightly recurved; medians smaller than the laterals, less than their radius apart, their diameter from the laterals. Area of median eyes subequal in length and breadth or slightly longer (11:10), narrower in front than behind in about ratio 9:10. Clypeus in height equal to length of median eye area. Epigynum as shown in Plate XVIII, Fig. 9.

Male—The palpal organ is distinctive. The spinulose submedian lobe, or apophysis, of the bulb is a notable feature. See Plate XVIII, Fig. 8.

Length of female, 3.8 mm. Length of cephalothorax, 1.8 mm.; width, 1.3 mm. Length of tibia + patella I, 1.4 mm.; of tibia + patella IV, 1.7 mm. Length of male, 2.8 mm.; of cephalothorax, 1.4 mm.

Type—M. C. Z. 448. Utah: Millard Co.; Clear Lake.

This species is readily recognizable by the form of the epigynum in the female and of the palpal organ in the male.

ARGIOPIDÆ.

Aranea (Neoscona) utahana sp. nov.

Female—This species belongs with *vertebrata* McCook in the group with longitudinal thoracic groove and having the anterior femora armed beneath with a double series of numerous stout spines. It differs from other forms of this group conspicuously in the form of the abdomen, which is rather broadly triangular-oval instead of elongate oval. The carapace grey of slightly yellowish cast marked with a conspicuous median longitudinal black band with lower border of pars cephalica also black followed on pars thoracica by one or more obscure dark spots. Sternum yellowish grey in the middle borders black. Abdomen grey with a folium on the posterior half limited on each side by a wavy black line edged with a pale line; just within the limiting line of folium on each side is a straight dusky line, while on the median region are two longitudinal dark lines close together; on each side of folium are numerous dark lines running from its edge ventrad; each anterolateral corner dark, the dark area crossed by fine vertical pale lines; midventral region black, the stripe embracing at each border two white spots, of which the anterior is the larger. Legs light yellow, deeply banded with black. The femur of anterior legs with a black submedian annulus and a broader distal one; the patella black, obscurely divided by a pale median area; the tibia with a black annulus at each end and one at the middle; and the metatarsus similarly triannulate. The tibiæ of legs III and IV lack the median black annulus as does metatarsus III, while it is present on metatarsus IV. Hairs of body in general whitish. The scape of the epigynum is in general similar to that of *vertebrata*, but is evenly curved, not at all geniculate. See Plate XIX, Figs. 1 and 2.

Length, 12 mm. Length of abdomen, 8.5 mm.; width across base, 8.2 mm. Length of cephalothorax, 5.2 mm. Length of tib. + pat. I, 7 mm.; of tib. + pat. IV, 6 mm.

Type—M. C. Z. 458. Utah: Fillmore. Webs found in sagebrush on desert flats west of the town. The color of the spiders blends with the olive grey of the sage-brush.

Aranea tusigia sp. nov.

Male—Carapace light brown above, the lower part of sides blackish brown with upper border of stripe serrate, a narrow marginal light stripe below dark area on each side. Sternum black. Legs yellow, marked with dark annuli; on femora a narrow annulus at base, a second broader one distad of middle and a third one toward distal end, the extreme distal end being of a reddish yellow cast. Tibiæ black at proximal end, at least above, and in a much broader annulus at distal end; metatarsi also dark at both ends, more narrowly so at the proximal one; tarsi darkened distally. Abdomen with folium above limited by a sinuous

light line on each side, the folium back of middle solid black and at its anterior end embracing a short median longitudinal stripe, which widens caudad; venter with a broad black stripe behind epigynum in each lateral edge of which is a yellowish spot; sides marked by fine longitudinal black lines or streaks. Thoracic furrow long, longitudinal, with no transverse impressions. The first coxa has a stout hook at distal end, while the second coxa is armed at base with a longer, stout, conical and nearly straight process. The tibia of leg II is enlarged with its mesal (anterior) surface convex; it is armed beneath with a double series of long stout spines, the posterior series in the type consisting of six spines and the anterior of three; the mesal or anterior surface in addition is armed with numerous spines in two or partially in three series, most of these spines being distad of the middle and these being much shorter and stouter than the others, about seventeen spines in all on the anterior surface. Palpus of male of characteristic form. See Plate XIX, Fig. 3.

Length, 8 mm. Length of cephalothorax, 4.2 mm. Length of tib. + pat. I, 5 mm.; of tib. + pat. IV, 4.2 mm.

Type—M. C. Z. 461. Utah: Chalk Creek.

CLUBIONIDÆ.

Clubiona orinoma sp. nov.

Female—Carapace dull yellow of slightly brownish cast. Sternum and legs light yellow. Labium and endites brown. Cheliceræ light chestnut. Abdomen beneath light yellowish grey; dorsum reddist brown over a yellow ground with a narrow median longitudinal reddish line from base to behind middle, this pointed at caudal end; sometimes fine pale chevron lines traceable on posterior region. Lower margin of furrow of chelicera armed with two moderately stout teeth with sometimes distad of these a number of granular elevations. Anterior row of eyes straight; eyes less than their radius from lower margin of clypeus, equidistant, nearly their diameter apart. Posterior row of eyes much longer than the anterior with eyes smaller; row straight; median eyes two and a half times their diameter apart, twice their diameter from the laterals. Area of median eyes much wider than long, wider behind than in front in about the ratio 22:15. Tibia I and II armed beneath with two pairs of spines, the corresponding metatarsi each with a single basal pair. Epigynum as shown in Plate XIX, Fig. 4.

Length, 6.5 mm. Length of cephalothorax, 2.6 mm. Length of tib. + pat. I, 2.2 mm.; of tib. + pat. IV, 2.2 mm.

Type—M. C. Z. 474. Utah: Chalk Creek.

AGELENIDÆ.

Agelena mimoides sp. nov.

Male—Carapace with the usual broad median longitudinal dorsal yellow stripe and yellow lateral stripes; a marginal dark line on each side; the lateral dark bands rather narrow, with lower edge uneven; eyes edged with black. Legs yellow, in type, with some vague darker markings on femora, but with not distinct annuli. Sternum yellow, a little deeper at the edges. Labium and endites darker, pale at tips. Cheliceræ light chestnut. Abdomen beneath immaculate light greyish yellow in middle region, an interrupted longitudinal dark line or series of dark spots toward each side; dorsally a broad longitudinal yellow stripe bordered with dark, the mesal edge of which is uneven or serrate and enclosing a vague saggittate outline in basal half. Lower margin of furrow of chelicera armed with two teeth as in *californica* and *pacifica*. Anterior median eyes smaller than the laterals, less than their radius apart and from the laterals. Posterior median eyes three-fourths or scarcely more their diameter apart, their diameter from the laterals. Tibia I armed beneath with three pairs of spines; tibia II with a single spine at base and a submedian and apical pair. The palpus of the male parallels in general structure that of *A. pacifica*. The most readily noted differences are in the tibia and its processes. In the dorsal view the excavation is seen to be more extensive, extending slightly farther mesad; the limiting posterior ridge presents a distinct process above which is always lacking in *pacifica* and in lateral view is seen to continue evenly out along the lateral apophysis, instead of showing an abrupt interruption. Other differences are noticeable in the details of the palpal organ. See Plate XIX, Figs. 5 and 6.

Female—The epigynum of the female is distinguished in having the posterior region more widely elevated with the lateral spurs weaker and more widely separated.

Type—M. C. Z. 464. Utah: Fillmore Canyon.

Cicurina garrina sp. nov.

Female—Carapace, sternum, and legs pale brown, the legs darker distally, the posterior pair somewhat chestnut. Labium, endites and cheliceræ chestnut. Abdomen immaculate grey. Eyes of anterior row equidistant, the medians about five-sevenths the diameter of the laterals. Posterior median eyes equal size to the anterior medians, the posterior laterals scarcely smaller than the anterior laterals. Posterior median eyes once and a half their diameter apart, their diameter from the lateral on each side. Cheliceræ strongly geniculate; lower margin typically with three stout teeth followed by three much smaller ones. Tibia I armed beneath with three pairs of spines, the anterior side with three single spines of which the most proximal one is subventral. Metatarsus I with three pairs of spines, the anterior face with two spines. Tibia II armed beneath with 1-1-2 spines. Epigynum, Plate XIX, Fig. 9.

Male—The palpus very similar to that of *C. arcuata*, but differing in details.

Length of female, 9 mm. Length of cephalothorax, 3.2 mm. Length of tib. + pat. I, 3 mm.; of tib. + pat. IV, 3.1 mm.

Type—M. C. Z. 470. Utah: Chalk Creek, elevation 8,000 ft.

A species much resembling the Louisianan *C. ludvoiciana* Simon in coloration, proportions and general structure. It may be distinguished in having the posterior median eyes much farther apart than from the laterals, instead of these eyes being equidistant, in having three spines on the anterior face of tibia I instead of but two; metarsus I with two spines on anterior side, instead of but one, etc.

Cicurina utahana sp. nov.

Female—A small form with carapace and sternum yellow, the legs more brownish especially distad. Carapace glabrous or nearly so. Abdomen grey, immaculate, the epigynum light chestnut. Lower margin of furrow of chelicera armed with four teeth, a minute fifth one detectable on one side in the type. Posterior row of eyes straight: median eyes smaller than the laterals, nearly their diameter from the latter, slightly farther from each other; posterior medians obviously smaller than in arcuata and the spacing of the posterior eyes more nearly equidistant. Epigynum, Plate XIX, Fig. 8.

Length, 5.2 mm. Length of cephalothorax, 2+mm. Length of tib. + pat. I, 1.8 mm.

Type—M. C. Z. 467. Utah: Millard Co.; Pine Canyon.

Cicurina utahana anderis subsp. nov.

Female—This form very much resembles in size and coloration the typical *C. utahana*. The epigynum is also very similar, but is proportionately smaller with the intermediate loop of the seminal duct on each side rising only a little farther forward than the ectal loop. The types differ from *utahana* in the spining of the anterior legs. Tibia I is armed beneath with three pairs of spines instead of two pairs, with two spines on the anterior face. Tibia II bears beneath three spines in line toward the caudal side with a fourth one paired with the most distal of these at distal end while on the anterior face is but a single spine; in utahana, on the other hand, there are but two spines beneath toward the caudal side with one distal spine not in line with these, while there are two spines on the anterior face.

Length, 6 mm. Length of cephalothorax, 2.1 mm. Length of tib. + pat. I, 1.8 mm.; of tib. + pat. IV, 2 mm.

Type—M. C. Z. 469. New Mexico: San Geronimo.

Cicurina idahoana sp. nov.

Female—Carapace and legs yellowish brown. Abdomen cinerous, without markings. Posterior row of eyes straight; eyes large, the medians smaller than the laterals; median eyes separated from the laterals by about their diameter, farther from each other. Anterior row of eyes procurved; medians smaller than the laterals, their radius or less apart, nearer to the laterals. Area of median eyes wider behind than in front, wider than long. Tibia I armed beneath with three pairs of spines and on the anterior face with three single spines of which two more proximal ones are much nearer to each other as usual. Metatarsus I armed beneath with three pairs of spines and with one spine on anterior face proximad of middle. Tibia II and Metatarsus II also armed beneath each with three pairs of spines. The species is readily recognizable by the structure of the epigynum (Plate XIX, Fig. 10).

Length, 7 mm. Length of cephalothorax, 3.1 mm. Length of tib. + pat. I, 3 mm.; of tib. + pat. IV, 3.2 mm.

Type—M. C. Z. 466. Idaho: Moscow Mts., J. A. Hyslop, coll., 1910.

LYCOSIDÆ.

Pardosa utahensis sp. nov.

Female—A small form apparently closely related to *P. emertoni* Chamb. It is a much darker species, though with the dorsal markings corresponding. Carapace with integument brown, with a straight black stripe along each side, a black marginal line and above it a heavier black supramarginal line; eye region black; the light stripes clothed densely with bright white hair, which is a little rufous about eyes. Sternum black, excepting a pale median region, instead of pale yellow with simply small marginal black dots. Legs dusky brown. Abdomen with dorsum black along each side, leaving a pale, caudally narrowing stripe over entire length, this enclosing anteriorly a dark hastate mark; venter dark grey; epigynum dark chestnut; light areas clothed in life with bright white hair. Anterior row of eyes much shorter than the second, about equalling the distance from center to center of the eyes of the latter; a little procurved; median eyes obviously more widely separated than in emertoni, clearly more than their diameter apart and less than their diameter from the laterals. Eyes of second row once and a half their diameter apart. Anterior tibiæ and metatarsi armed beneath as usual, the first two pairs of spines being very long and slender with the first widely overlapping the second. Epigynum as shown in Plate XIX, Fig. 11.

Length, 6.5 mm. Length of cephalothorax, 2.9 mm. Length of tib. + pat. I, 3 mm.; of tib. + pat. IV, 3.6 mm.

Type—M. C. Z. 385. Utah: Chalk Creek, elevation 8,000 ft., August, 1917.

EXPLANATION OF PLATES.

PLATE XIV.

Fig. 1. Epigynum of *Amaurobius nomeus* sp. nov.
Fig. 2. Male palpus, dorsal view, of the same.
Fig. 3. Right chelicera, ectal view, of *Dictyna uintana* sp. nov.
Fig. 4. Epigynum of the same.
Fig. 5. Right male palpus, ectal view, of the same.
Fig. 6. Left chelicera, of male, ectal view, of *Dictyna coloradensis* sp. nov.
Fig. 7. Epigynum of the same.
Fig. 8. Right male palpus, ectal view, of the same.

PLATE XV.

Fig. 1. Epigynum of *Dictyna vincens* sp. nov.
Fig. 2. Right male palpus, ectal view, of the same.
Fig. 3. Right chelicera, ectal view, of *Dictyna bellans* sp. nov.
Fig. 4. Epigynum of the same.
Fig. 5. Right male palpus, ectal view, of the same.
Fig. 6. Right male palpus, ectal view, of *Dictyna insolens* sp. nov.
Fig. 7. Right male palpus, ectal view, of *Dictyna olympiana* sp. nov.
Fig. 8. Epigynum of *Dictyna sociella* sp. nov.

PLATE XVI.

Fig. 1. Epigynum of *Dictynoides arizonensis* sp. nov.
Fig. 2. Epigynum of *Drassodes robinsoni* sp. nov.
Fig. 3. Left male palpus, ectal view, of *Drassodes gosiutus* sp. nov. (All hairs and spines omitted as usual, excepting ventral distal spines of tarsus.)
Fig. 4. Left male palpus, ectal view, of *Drassodes melius* sp. nov.
Fig. 5. Epigynum of the same.
Fig. 6. Left male palpus, ectal view, of Heryullus oabus sp. nov.
Fig. 7. Epigynum of Zelotes tuobus sp. nov.

PLATE XVII.

Fig. 1. Right male chelicera, ectal view, of *Psilochorus utahensis* sp. nov.
Fig. 2. Right male palpus, ectal view, of the same.
Fig. 3. Left male palpus, ectal view, of *Linyphia latescens* sp. nov.
Fig. 4. Epigynum of *Linyphia orinoma* sp. nov.
Fig. 5. Epigynum of *Bathyphantes fillmorana* sp. nov.
Fig. 6. Epigynum of *Grammonota obesior* sp. nov.
Fig. 7. Epigynum of *Grammonota orites* sp. nov.
Fig. 8. Right male palpus, ectal view, of the same.
Fig. 9. Right male palpus, dorsal view, of the same.

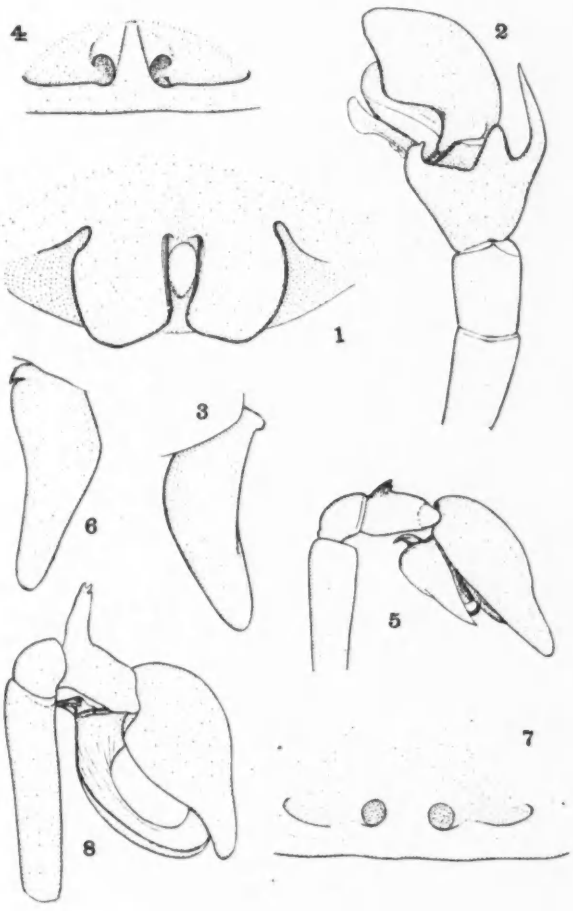
PLATE XVIII.

Fig. 1. Left male palpus, ectal view, of *Grammonota simplex* sp. nov.
Fig. 2. Epigynum of the same.
Fig. 3. Epigynum of *Grammonota fratrella* sp. nov.
Fig. 4. Epigynum of *Cornicularia monticolens* sp. nov.

Fig. 5. Left male palpus, ectal view, of the same.
Fig. 6. Left male palpus, ectal view, of *Diplocephalus wamotsus* sp. nov.
Fig. 7. Epigynum of the same.
Fig. 8. Left male palpus, ectal view, of *Hilaira uta* sp. nov.
Fig. 9. Epigynum of the same.
Fig. 10. Right male palpus, dorsal view, of *Wubana retrahens* sp. nov.

PLATE XIX.

Fig. 1. Epigynum, ventral view, of *Aranea utahana* sp. nov.
Fig. 2. Epigynum, lateral view, of the same.
Fig. 3. Left male palpus, ectal view, of *Aranea tusigia* sp. nov.
Fig. 4. Epigynum of *Clubiona orinoma* sp. nov.
Fig. 5. Right male palpus, ectal view, of *Agelena mimoides* sp. nov.
Fig. 6. Tarsus of right male palpus, dorsal view, of the same.
Fig. 7. Epigynum of *Agelena naevia* Hentz, variety (Uintah Mts.)
Fig. 8. Epigynum of *Cicurina utahana* sp. nov.
Fig. 9. Epigynum of *Cicurina garrina* sp. nov.
Fig. 10. Epigynum of *Cicurina idahoana* sp. nov.
Fig. 11. Epigynum of *Pardosa utahensis* sp. nov.



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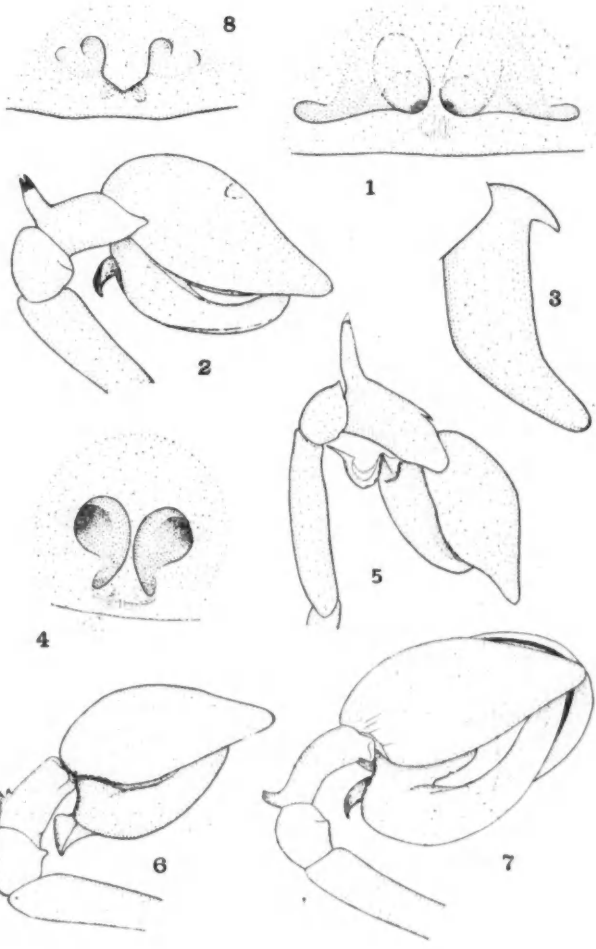

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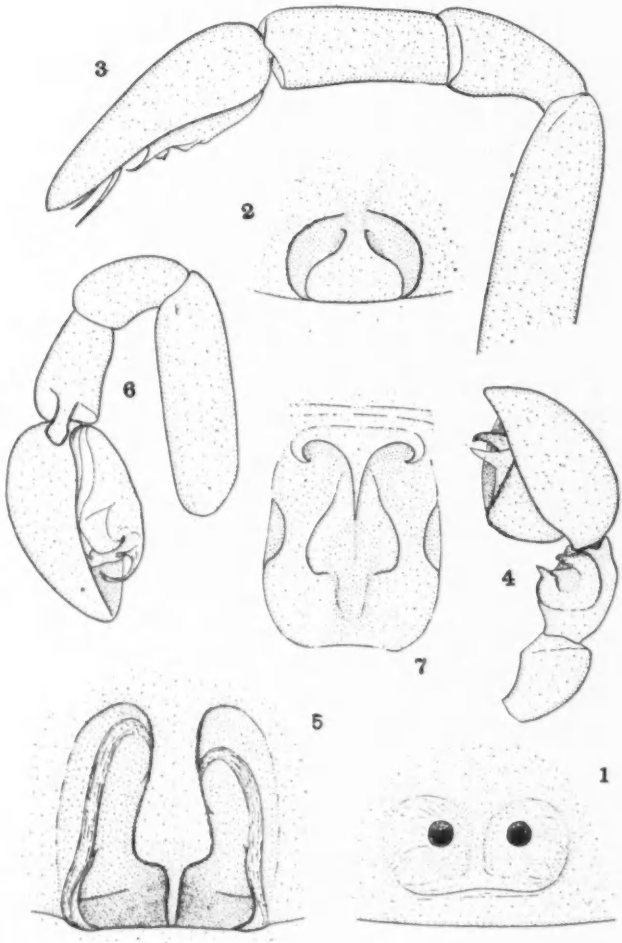

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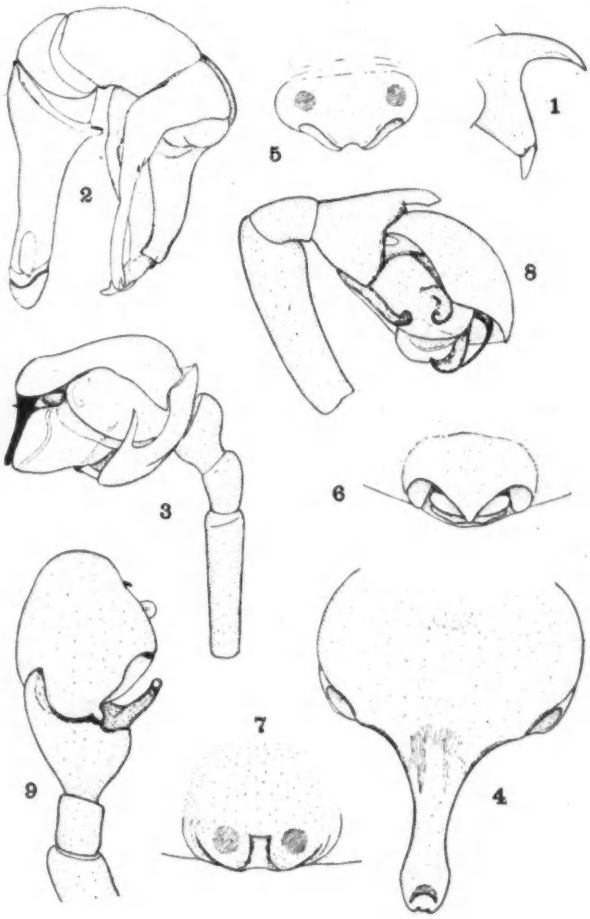

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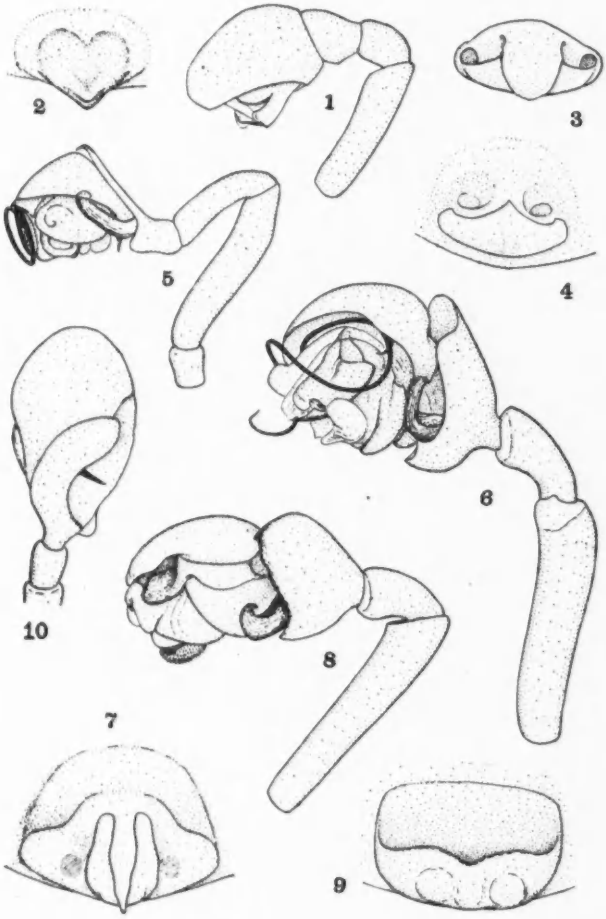

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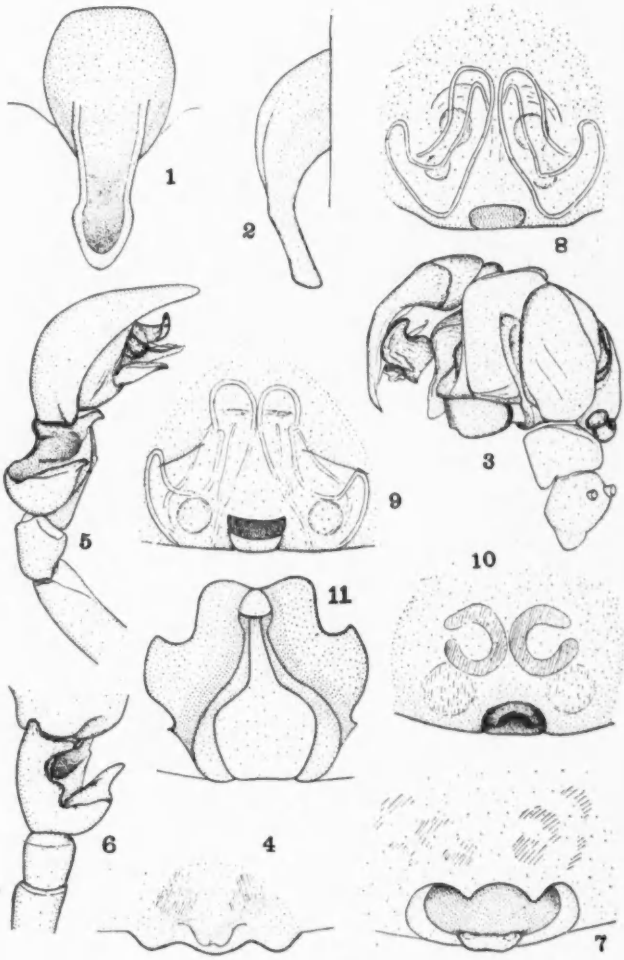

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